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SURGERY

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SURGERY

VOL. 39 MAY, 1956 NO. 5

Original Communications

STUDIES IN THE RECOGNITION OF STRANGULATING INTESTINAL OBSTRUCTIONS WITH SPECIAL REFERENCE TO THE VALUE OF PNEUMOPERITONEOGRAPHY

JOHN F. PERRY, JR., M.D.,* STANLEY C. VONDRASHEK, M.D.,** AND OWEN H. WANGENSTEEN, M.D., MINNEAPOLIS, MINN.

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A RECENT survey of patients with intestinal obstruction has shown that 75 per cent of strangulating obstructions were diagnosed and correctly treated without delay; in the remainder, insufficient clinical and radiographic findings had been present at the time of hospital admission to lead to immediate recognition of the condition. The importance of early diagnosis here is obvious, for among patients with strangulating obstructions treated before gangrene occurred, the mortality rates were no greater than in nonstrangulating obstructions. In strangulating obstructions which had progressed to gangrene, however, mortality rates were four to five times greater.[6]

Typical clinical signs suggesting the diagnosis of intestinal strangulation do not occur in all patients with this condition. In our experience, abdominal tenderness has been the most constant of these signs, yet this occurrence has been noted in only 86 per cent of patients with strangulation of the bowel. The next most common sign, leukocytosis above 10,000, was present in only 65 per cent of our cases. Intestinal colic,† rebound tenderness, and elevated temperature (over 100° F.) were each found in less than half of the patients. A search by the patient for a position of comfort accompanied by the presence of intestinal colic and abdominal tenderness frequently suggests the presence of intestinal strangulation. Patients having intestinal colic who plead for pain relief are very likely to have strangulating obstructions. The inconstancy

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†Intestinal colic: concomitant occurrence of colicky pain and intestinal borborygmi.

of some of these telltale signs and the lack of an objective confirmatory sign, these are items which have contributed to delay in the recognition of strangulating obstructions.

Conventional radiologic studies, in the main, also too frequently have been inconclusive in strangulating obstruction. There may be only a few scattered and isolated areas of gas in the small bowel in an otherwise relatively gasless abdomen, making the detection of intestinal obstruction difficult or impossible. In some cases, fluid-filled coils of small bowel may be visible on the scout film, but often the presence of peritoneal fluid and fat cause an opacity that is difficult to interpret.

Frimann-Dahl (1944)[2] has stressed the importance of the "pseudo-tumor sign" in the recognition of strangulating obstructions. Rigler (1944),[4] and Mellins and Rigler (1954)[3] described the "coffee-bean sign" and reported that these, or corollary roentgen signs, were present in 85 per cent of cases reviewed by them. In almost 60 per cent of instances, visualization of the strangulated loop itself was possible. Nonetheless, general experience suggests that interpretation of x-ray findings remains difficult and uncertain in many cases.

THE PRESENT STUDIES

Over a period of two years, several techniques have been under experimental scrutiny in the hope of finding an objective corroborative test of the presence of a strangulating obstruction. One of these, pneumoperitoneography, has shown sufficient promise to warrant a clinical trial in patients. Our experience suggests that pneumoperitoneum is a very helpful adjunct to the usual roentgen technique in the recognition of strangulating obstructions. It is this experience which justifies this report.

Aortography.—This experiment was done to determine whether or not a strangulated, closed loop could be recognized by a distortion of the mesenteric vascular pattern. Strangulated loops of Type A (Fig. 1) were produced surgically in 2 dogs. After four hours, a catheter was inserted via the femoral artery into the thoracic aorta and aortograms were made. Although the mesenteric vessels were well filled and the smaller arterial radicles visualized, in neither animal could the strangulated loop be detected and no distortion of the vascular pattern was apparent. Both animals had enlarged, severely hemorrhagic loops at autopsy.

Radiopaque Media.—Hemorrhage into the strangulated loop is a feature of all strangulating obstructions in which the venous component predominates. Experiments were carried out to determine whether or not an opaque medium given intravenously would be retained sufficiently by hemorrhage into the loop to render the loop opaque to roentgenograms. After a strangulated loop of Type B (Fig. 1) had been created, the opaque medium was given slowly intravenously. In 4 dogs, utilizing 3 different intravenous contrast media (colloidal thorium dioxide, lead versenate, Diodrast), there was no visualization of the strangulated loop in the radiograph.

Radioisotope-tagged Red Blood Cells.—Chromium-tagged (Cr^{51}) red blood cells were injected intravenously forty-eight hours prior to the experiment. Baseline counts were made over the abdomen at 6 sites with a Geiger-Müller counter; a venous closed-loop obstruction of a segment of ileum 12 cm. in length was then established in 5 dogs. The strangulated loop was replaced in the abdomen, and counts were repeated at the same sites at thirty-minute intervals. Although there was some suggestion that the concentration of Cr^{51} increased sufficiently due to extravasation of blood into the wall and lumen of

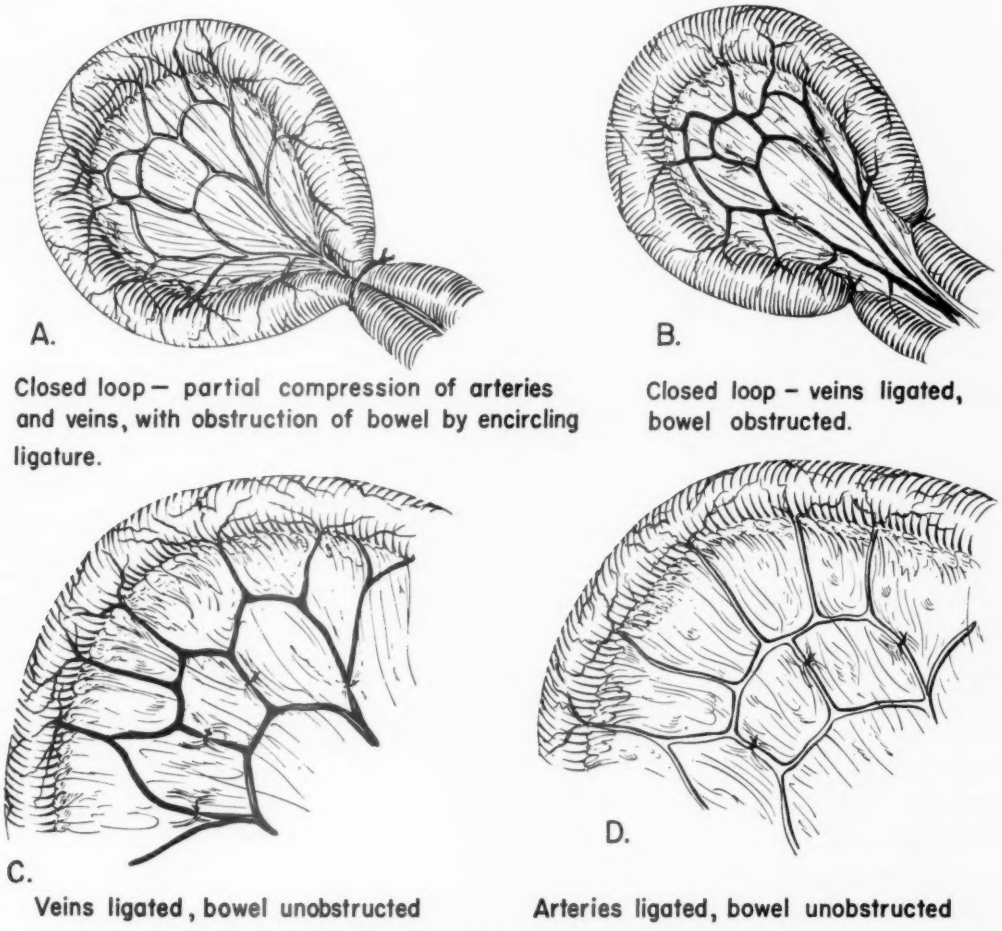

A.
Closed loop – partial compression of arteries and veins, with obstruction of bowel by encircling ligature.
B.
Closed loop – veins ligated, bowel obstructed.
C.
Veins ligated, bowel unobstructed
D.
Arteries ligated, bowel unobstructed

Fig. 1.—Types of strangulating lesions produced experimentally in dogs.

the loop, to cause a detectible rise in the count over the loop itself, variations of the blood content of the abdominal viscera, especially liver and spleen, caused such variations in counts over other areas of the abdomen that the method was abandoned as not sufficiently accurate to warrant further pursuit.

Pneumoperitoneography.—Operation was carried out in dogs and strangulating lesions of the four types shown in Fig. 1 were created. Radiographic examination was carried out one to twenty-nine hours after operation. After scout films had been made in various projections, pneumoperitoneum was in-

duced through a small polyethylene tube which had been passed through a 15-gauge needle. From 500 to 1,000 ml. of air was introduced by syringe and films were again taken.

TABLE I. VISUALIZATION OF EXPERIMENTAL STRANGULATING LESIONS BY PNEUMOPERITONEOGRAPHY

DOG	TYPE OF OBSTRUCTION (SEE FIGURE 1)	DURATION OF OBSTRUCTION (HOURS)	INTERPRETATION OF ROENTGENOGRAMS	
			PLAIN FILMS	PNEUMOPERITONEOGRAM
897	A	5	Nondiagnostic	Loop visible
1052	A	1	Nondiagnostic	Loop visible
521	A	3	Nondiagnostic	Loop visible
505	A	5	Nondiagnostic	Loop visible
823	B	4-5	Nondiagnostic	Nondiagnostic
720	B	4	Nondiagnostic	Nondiagnostic
392	B	6	None	Loop visible
628	B	5	Nondiagnostic	Loop visible
697	B	5	Pseudo-tumor sign	Loop visible
1559	B	1½	Pseudo-tumor sign	Loop visible
732	B	4	Nondiagnostic	Loop visible
789	B	1½	Pseudo-tumor sign	Pseudo-tumor sign
1130	C	1½	Nondiagnostic	Nondiagnostic
734	C	6	Nondiagnostic	Nondiagnostic
734	C	29	Pseudo-tumor sign	Large mass of adherent loops
762	C	4	Nondiagnostic	Loop visible
637	D	4	Nondiagnostic	Nondiagnostic
738	D	5	Nondiagnostic	Nondiagnostic
767	D	5	Nondiagnostic	Nondiagnostic
845	D	6	Nondiagnostic	Nondiagnostic

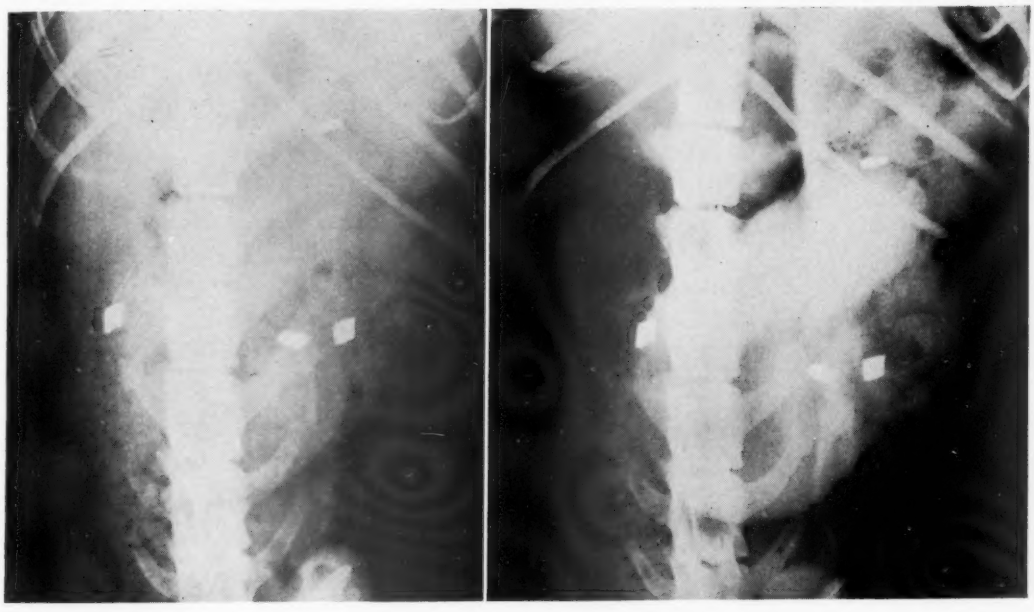
Table I shows the results obtained in the various types of strangulations. The edematous or hemorrhagic, fluid-filled, closed loops (Type A and B, Fig. 1) were usually readily demonstrated after pneumoperitoneum although these loops could not be detected on scout films or, at best, only a gasless area or a suggestion of "pseudo-tumor" was visible. In the pneumoperitoneogram, such loops appeared as sausage-shaped, densely homogeneous masses which contrasted sharply with the appearance of normal small bowel loops. Examples of the appearance of loops in supine pneumoperitoneograms as contrasted with the supine scout films are shown in Figs. 2 and 3. The supine position has given the most helpful information.

The results were much less definite in venous infarctions without obstruction of the intestinal lumen (Type C, Fig. 1). Although a loop could be seen in the pneumoperitoneogram of one animal so prepared, in two others the results were not conclusive.

In arterial infarctions (Type D, Fig. 1) the method was not diagnostic as this type of strangulating lesion did not cause sufficient increase in mass of the bowel loop to be differentiated from normal small bowel loops in the pneumoperitoneogram.

These differences in mass density of the bowel are quite understandable in the light of the studies made by Scott and Wangensteen in this clinic many years ago (1932).[5] Following venous strangulations of the intestine of less than six hours' duration, they observed increases in weight of the strangulated

segments exceeding equal lengths of normal segments by 150 to 490 per cent. The average increase was 283 per cent. No increase in weight of the infarcted segment was observed in arterial strangulations over a fifteen-hour period of observation. It is hemorrhage into the lumen and wall of the venous strangulations which accounts for the differences in mass, which circumstance, in turn, is responsible for the appearance of the venous strangulated segment in the pneumoperitoneogram.



A. *B.*

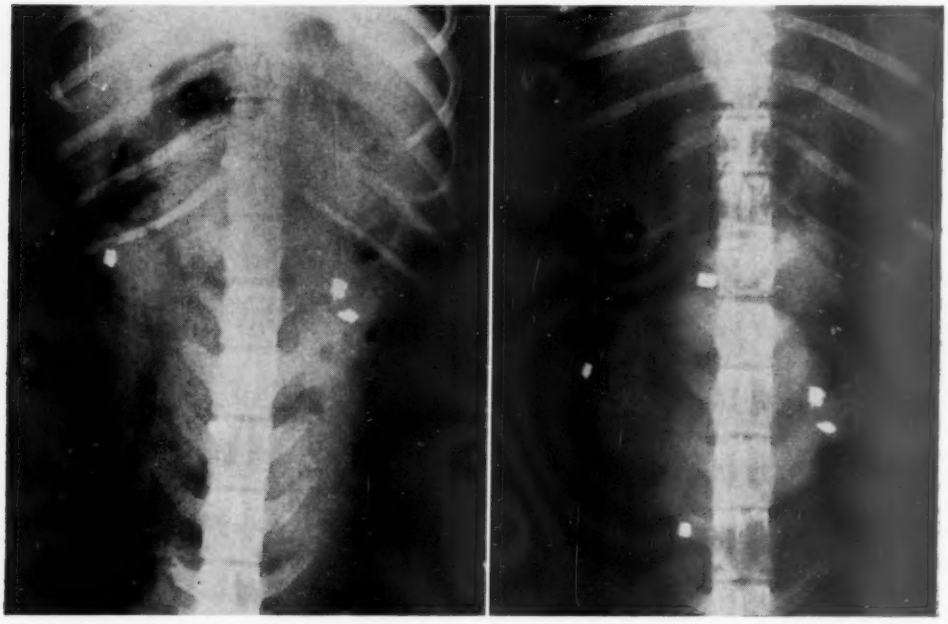
Fig. 2.—Dog No. 1559. *A*, Scout supine radiograph. A pseudo-tumor is visible in the mid-abdomen. Lead markers are attached to the strangulated loop. *B*, Pneumoperitoneogram taken after 1,000 ml. of air had been introduced. The strangulated loop is visible in the mid-abdomen.

Radiopaque media (Diodrast, thorium dioxide, or lead versenate) were given intravenously to four dogs after strangulating obstruction (Type A, Fig. 1) had been produced. No discernible improvement in demonstrating such strangulated loops by pneumoperitoneography was noted. Currently, attempts to demonstrate arterial strangulations by variants of these techniques are being studied.

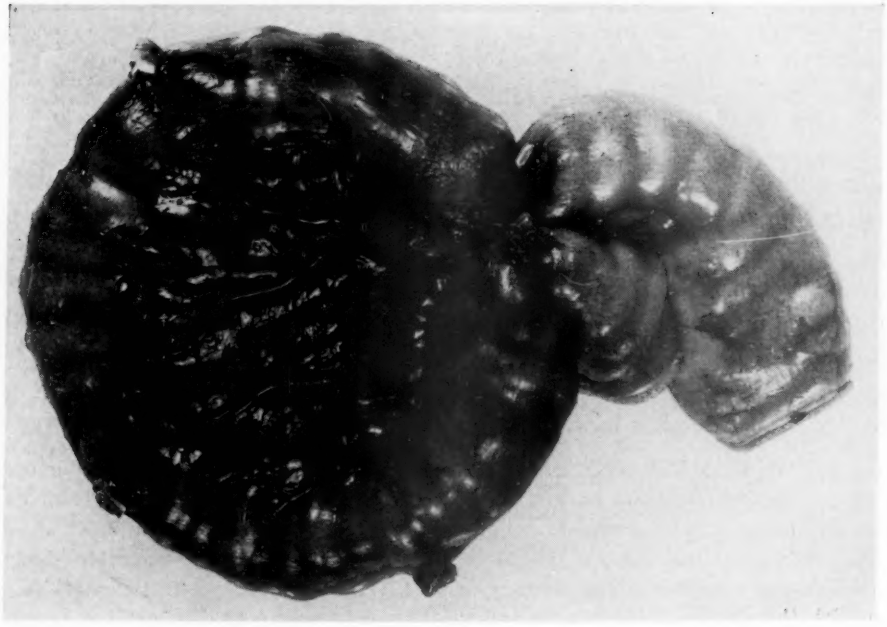
Three examples of the application of pneumoperitoneography to strangulating intestinal obstructions in man are given below:

CASE 1.—(E. H. UMH #872613). A 73-year-old man entered with a fourteen-hour history of cramping abdominal pain. One year earlier he had undergone a total gastrectomy for carcinoma of the stomach. On admission his temperature was 98.6° F. There was lower abdominal tenderness, slight rebound tenderness, and moderate abdominal distention. A polymorphonuclear leukocytosis of 17,700 was present. Scout films of the abdomen with the patient lying supine and in the erect posture showed neither gaseous nor fluid distention of the bowel. A few bubbles of bowel gas which were present appeared displaced away from a quite uniformly gray area in the central abdomen suggesting a pseudotumor. Shortly after these films were made, 650 ml. of gas (oxygen, in this instance)

was introduced and pneumoperitoneograms were made in a variety of positions. As in the dogs, the supine film was the best. It demonstrated small bowel coils greatly distended with fluid resulting from volvulus of a long small bowel segment. A torsion of the mesentery across an adhesive band had obstructed the venous return of the central three-fifths of the small intestine. At surgery this fluid-filled loop was two and one-half times normal



A. *B.*

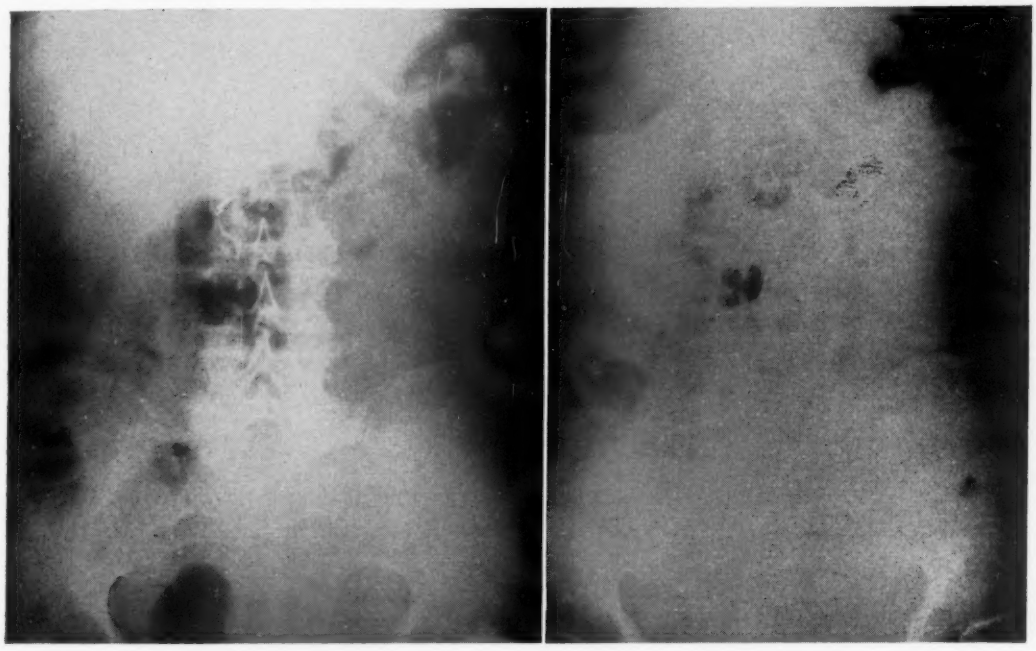


C.

Fig. 3.—Dog No. 521. *A*, Supine radiograph made before introduction of air. The loop is not shown. *B*, Pneumoperitoneogram after 500 ml. air. *C*, Strangulated excised segment.

size and dark purplish red. Ninety centimeters of bowel was resected because the strangulated loop was nonviable. The patient recovered uneventfully. Fig. 4 shows the scout films and pneumoperitoneogram taken in the supine position.

CASE 2.—(J. P. #892325). This 72-year-old man had had two earlier operations for intestinal obstruction. During the week before admission here, he had diffuse abdominal

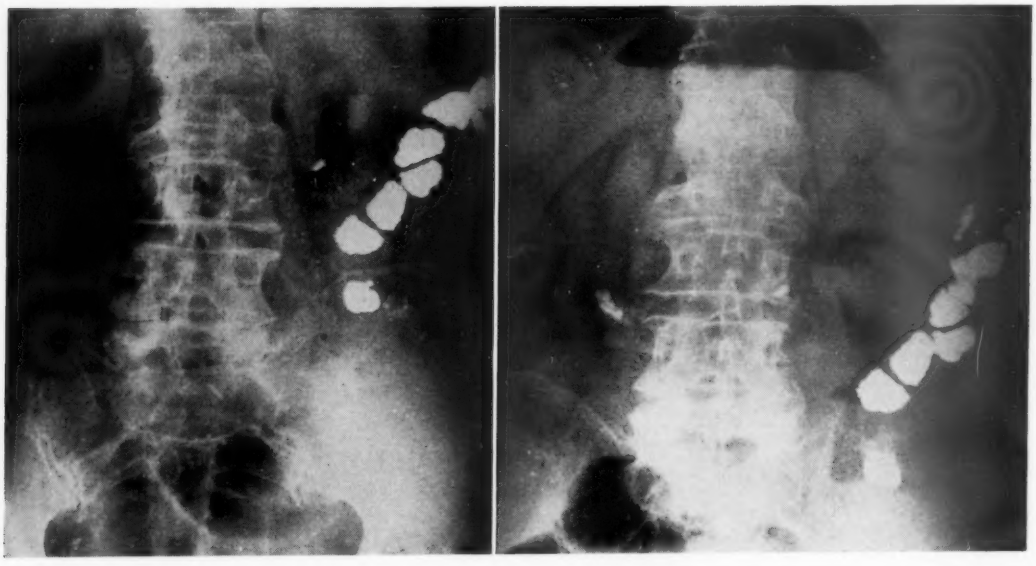


A. *B.*

C.

Fig. 4.—E. H. (U. H. No. 872613). *A*, and *B*, Scout supine and upright films. A hazy gasless area is shown in the left lower abdomen. *C*, Pneumoperitoneogram (supine) after 650 ml. of gas. The infarcted segment of small bowel is clearly visible.

pain, vomiting, and obstipation. For five days he had been hospitalized elsewhere. On admission, his abdomen was distended and slightly tender. Bowel sounds were hypoactive, infrequent, and high-pitched. Temperature was 99.4° F. His white blood count was 11,050. Initial films (Fig. 5, *A* and *B*) show residual barium in the left colon from an



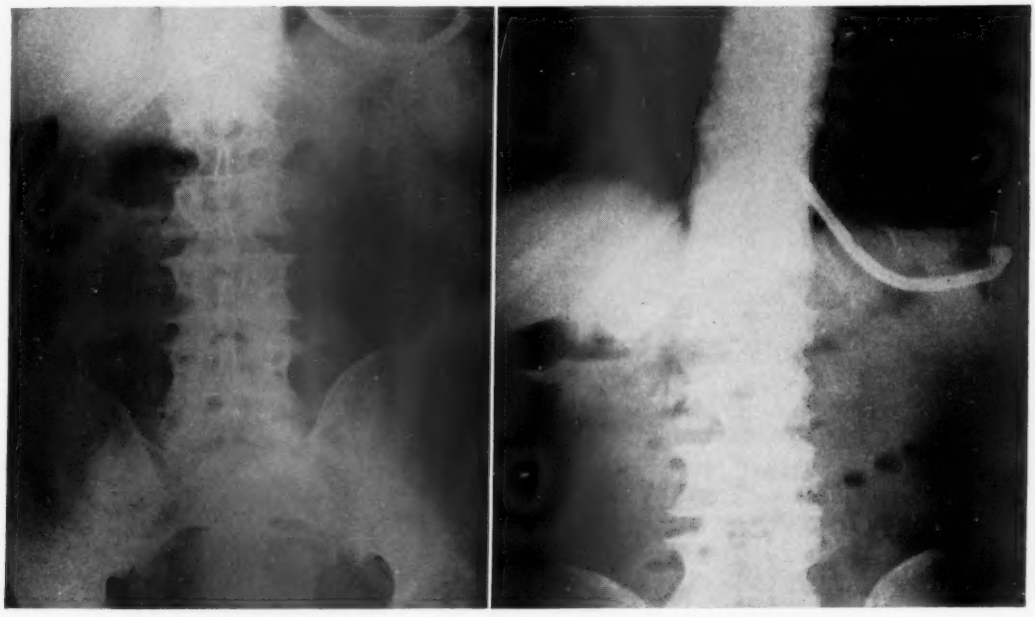
A. *B.*

C.

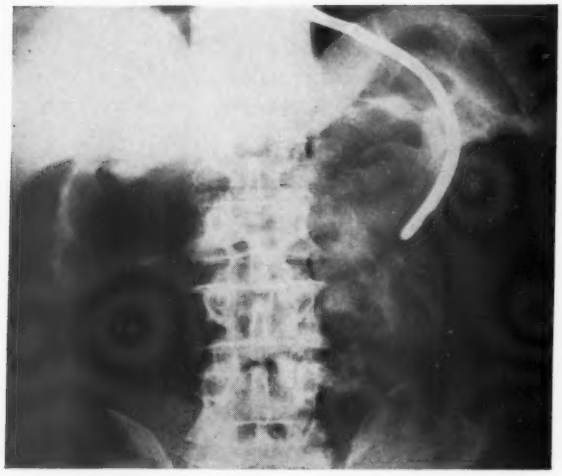
Fig. 5.—J. P. (U. H. No. 892325). *A*, Scout supine film. *B*, Upright abdominal film shows a long fluid level in the upper midabdomen suspicious of a large loop. *C*, Pneumoperitoneogram (supine) after introduction of 600 ml. of air. The strangulated loop is clearly visible in the upper abdomen.

examination done before admission. Gas and fluid are visible in the stomach and a number of small gas-fluid levels are seen in the left upper and right lower abdomen. On the upright film, a long fluid level is visible high in the central abdomen.

We were not sure which viscus this represented but we were suspicious of a small bowel loop greatly dilated with fluid. This was quickly proven by introducing 600 ml. of gas by syringe (Fig. 5, *C*). The enormous small bowel loop which is shown in the upper abdomen was a volvulus of the proximal reaches of the ileum under an omental band. The loop was tense, greatly dilated, and gangrenous. It had perforated, sealing itself against the gastric antrum. The postoperative course was stormy, complicated first by uremia and



A. *B.*



C.

Fig. 6.—H. M. (U. H. No. 889616). *A* and *B*, Scout supine and upright radiographs. *C*, Pneumoperitoneogram. The strangulated loop is visible in the central abdomen on the left.

later by a cerebrovascular accident. The latter occurrence caused death on the twenty-seventh postoperative day. At autopsy, a small residual subhepatic abscess was still present.

CASE 3.—(H. M. #889616). This 70-year-old white man was admitted complaining of upper abdominal pain. For the past three months he had been in and out of the hospital for treatment of complications arising from a perforated duodenal ulcer. As a result of this, he had undergone several abdominal operations. On the present admission he denied other symptoms. There was upper abdominal tenderness but no distention. He experienced more comfort lying on his right side. His white blood count was 16,700 with 76 per cent polymorphonuclear leukocytes. Fig. 6, *A* and *B*, shows the supine and upright abdominal scout films. The pneumoperitoneogram (Fig. 6, *C*) shows the strangulated loop. At operation, a volvulus of the ileum due to adhesions was found.

He recovered uneventfully. He has since been hospitalized on the Urology Service for definitive treatment of urinary retention secondary to prostatic hypertrophy.

DISCUSSION

Many references are present in the literature concerning the use of pneumoperitoneum, but we have found none relating to its application in the diagnosis of strangulating obstructions. It was used quite extensively in the 1920's after popularization by Stewart and Stein,[7] but was soon generally abandoned, probably because of the improvement in scout films after introduction of techniques utilizing the Potter-Bucky diaphragm. In this clinic in earlier years pneumoperitoneum has been used in two areas of interest in the bowel obstruction problem: (1) in the detection of adhesions, and (2) as a prophylactic agent against adhesion formation in so-called "adhesion formers" following severance of the bands and lysis of the bowel. Both these techniques are described and illustrated in all 3 of the editions (1937, 1942, 1955) of a monograph on bowel obstruction emanating from this clinic.[8]

The dangers of puncture of vessels or viscera, infection, tissue emphysema, air embolism, and precipitation of cardiac failure through overdistention of the abdomen have been enumerated by Case[1] and other early workers. However, in recent years pneumoperitoneum has been used in many thousands of patients with pulmonary tuberculosis and would appear to be in itself a reasonably safe procedure. In one instance, the bowel was perforated by the needle and the polyethylene catheter was threaded into the bowel. It was left in place and the patient was subjected to immediate surgery and with a happy result. That clinical signs may be obscured by pneumoperitoneum has been recognized. Clinical application has as yet not been sufficiently extensive to warrant definite conclusions as to when this procedure can best be applied in patients, suspected of having intestinal obstruction of the strangulating variety. It would appear that the abdomen which is relatively gasless in the abdominal scout film and in which signs of strangulation are inconclusive would be the optimal situation for its application to demonstrate closed loops. However, its use would appear to be indicated in all instances in which the diagnosis is inconclusive.

We believe, in the light of our own experience, that it is not venturesome to suggest that timely use of this diagnostic aid in internal strangulations will

result in definite improvement in accomplishment in a segment of the obstruction problem, which continues to be responsible for a large share of the mortality of intestinal obstruction. Even puncture of the bowel is far less hazardous than overlooking a strangulated intestinal loop.

TECHNIQUE

Air is introduced by passing a 15-gauge needle through a procaine wheal in the skin of the abdominal wall. After the parietal peritoneum has been penetrated, a small bore polyethylene tube is introduced through the needle and 8 to 10 cm. are threaded into the peritoneal cavity. The needle is then withdrawn over the tube, leaving it in place. This reduces the chance of visceral injury or extraperitoneal injection. The site of election for placement of the needle has been the right lower quadrant. In the presence of many prior abdominal incisions, any suitable alternative site may be selected. Small volumes of air, less than 1,000 ml., have been enough to demonstrate strangulating lesions in patients without causing discomfort.

SUMMARY

An attempt has been made to demonstrate the presence of strangulated intestinal loops by several methods in experimental animals. Of these, radiographs of the abdomen taken after the introduction of intraperitoneal air have been most successful.

Pneumoperitoneograms have demonstrated closed loop obstructions most clearly. Simple venous infarctions were less well visualized, and arterial infarctions could not be differentiated from normal intestine.

Case histories of 3 patients with strangulating obstructions due to volvulus of the small bowel are included. In each, the strangulated intestinal segment was clearly demonstrated by pneumoperitoneogram.

We believe that use of this method will result in earlier detection of strangulating intestinal obstructions, a practice which, if adopted by the profession, could come to make an imprint for the better upon a sector of the bowel obstruction problem in which the current accomplishment is poor.

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DIAGNOSTIC SIGNIFICANCE OF RADIOACTIVE ISOTOPES IN EARLY CANCER OF THE ALIMENTARY TRACT, ESPECIALLY THE ESOPHAGUS AND THE CARDIA

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IN THE present day, a cure of cancer, especially in the alimentary tract, is attainable only by surgical removal of the entire lesion at an early date. Hence, early detection and early diagnosis are indeed invaluable and important prerequisites to enhancing its curability.

In order to diagnose malignancy in the alimentary tract, we have resorted chiefly to roentgenologic and endoscopic studies and smear and other tests, diagnoses being made solely on the basis of the morphologic traits of malignancy. The unreliability of basing a diagnosis of malignancy in the alimentary tract solely on its morphologic features has been appreciated for some time, and its main causative factors have lain in the shortage of training and equipment necessary for this study. It is especially true in the early cases in which neoplasm in the alimentary tract is still limited to a small segment and the findings are often too minimal to detect. It has not been infrequent for physicians to encounter difficulties in establishing a correct diagnosis and to note the fallibility of preoperative diagnoses. In contrast to these conventional methods, the diagnostic method proposed herein for tumors in the alimentary tract, and especially for early cases, involves the radioactive isotope P^{32}, and its principle is based entirely upon a biochemical feature of malignancy, the markedly selective uptake of P^{32} by malignant tissues, attributable to the enhanced metabolism of malignant cells.

As to the selective uptake of P^{32} by malignant tumors, there have been reports on animal experiments by Jones, Chaikoff and Lawrence (1940),[2] and also by Lawrence, Erf and Tuttle (1941). In human subjects, this phenomenon was studied by Kenney, Marinelli, and Woodard[3] with cancer of the breast, and also by Schulman, Falkenheim and Gray (1949)[9] with removed specimens of malignancy. Studies in Clinical application were done by Low-Beer for the diagnosis of breast cancer (1946, 1948),[4-6] and by Selverstone and associates (1948)[10] for the diagnosis of brain tumors. Both groups of investigators were able to prove the merit of the method. Nevertheless, little heed has been taken of the opportunity of studying malignancy in the alimentary tract with the tagged isotope. It is the purpose of the author to stress the significance of similar studies with radioactive P^{32} in the recognition of malignancy of the alimentary tract.

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*Professor of Surgery.

FUNDAMENTAL STUDIES

1. The selective uptake of radioactive phosphorus by malignant tissues gives us the basis for this diagnostic method. Chemical analysis was attempted in order to prove this biochemical feature of malignant tissues.

2. Histologic investigation was done to confirm the determining factors for the higher counting rates of malignant tissues.

3. Radioautographs were prepared to demonstrate the affinity of malignant tissues for P^{32}.

Chemical Analysis.—

P^{32} for total sample collected: An aliquot (1 Gm.) of both cancerous and normal tissues (obtained after administration of P^{32}) was weighed and treated by the wet-ashing procedure, and then precipitated by means of a magnesia mixture. After desiccating, each aliquot was measured by counts per minute with a Geiger-Müller counter. This study revealed the following results:

TABLE I.

DISEASE	NO. OF CASES	RATIO OF COUNTS PER MINUTE (CANCER/NORMAL)	AVERAGE
Cancer of the esophagus	7	2.4 to 3.3	2.9
Cancer of the stomach	10	1.6 to 3.3	2.6
Cancer of the rectum	5	1.6 to 2.9	2.4

These data were sufficient to confirm the active uptake of P^{32} by malignant tissues.

P^{32} Fractions.—Known aliquots (1 Gm.) of both cancerous and normal tissues, obtained from fresh specimens of patients undergoing administration of P^{32}, were weighed and separated into such phosphorus fractions as acid-soluble phosphorus, lipid phosphorus, and nucleotide and phosphoprotein fractions by means of the Schmidt-Thannhauser method. The counts per minute of the P^{32} contained in each phosphorus fraction thus obtained were measured with the Geiger-Müller counter, and the counting ratio of cancerous tissue to normal tissue was compared in each fraction. The counting ratio thus obtained for the esophagus in 5 cases is as indicated in Table II in which it is obvious that malignant tissues contain much more phosphorus than normal tissues in each phosphorus fraction. A more detailed analysis of the nucleotide fraction revealed that the following two components were found in enormously large amounts in malignant tissues of the esophagus. Desoxyribonucleic Acid, D.N.A., which participates in mitotic activity, was found 3.3 times more in amount in malignant tissues than in normal tissues, and Ribonucleic Acid, R.N.A., which participates in intracellular metabolism, was found in concentrations 2.5 times greater than in normal tissue.

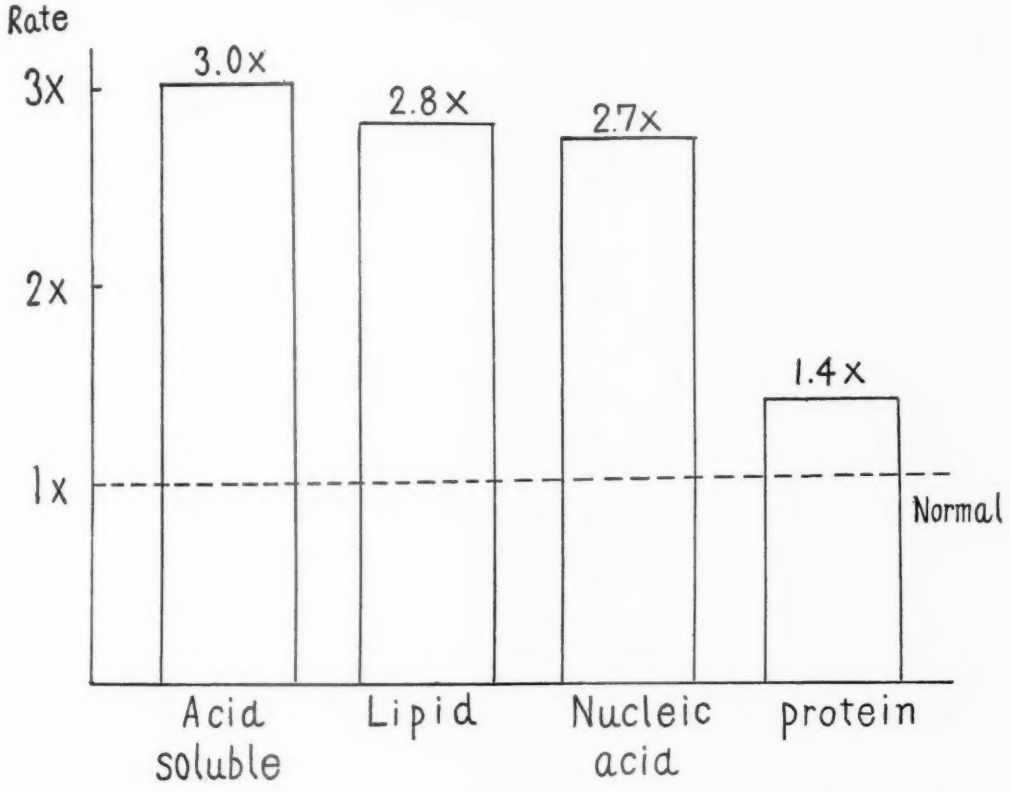
The same chemical analysis was done in 8 cases with cancer of the stomach, and the results which are as tabulated in Table III resemble those of the esophageal cancer. D.N.A. was found to average 3.3 times the normal content, and R.N.A. found 2.5 times. The studies seem to indicate that: (1) intracellular metabolism of malignant tissues is enormously enhanced and (2) the

TABLE II(*A*). P^{32} FRACTIONS (5 CASES OF ESOPHAGEAL CARCINOMA)

NO. OF CASE	ACID SOLUBLE P^{32}			LIPID P^{32}			NUCLEIC ACID P^{32}			PROTEIN P^{32}		
	CANCER C.P.M./ GR.	NORMAL C.P.M./ GR.	RATIO CANCER/ NORMAL	CANCER C.P.M./ GR.	NORMAL C.P.M./ GR.	RATIO CANCER/ NORMAL	CANCER C.P.M./ GR.	NORMAL C.P.M./ GR.	RATIO CANCER/ NORMAL	CANCER C.P.M./ GR.	NORMAL C.P.M./ GR.	RATIO CANCER/ NORMAL
1	1745	965	1.81	92.4	36.5	2.53	299.8	72.7	4.13	104.2	56.7	2.01
2	2481	1008	2.47	80.7	48.1	1.68	333.2	131.4	2.65	121.0	85.4	1.42
3	2568	823	3.12	245.1	85.4	2.85	229.8	108.1	2.05	78.1	58.4	1.34
4	2758	653	4.23	236.9	63.2	3.28	283.8	111.7	2.56	135.1	98.6	1.37
5	2962	847	3.51	390	51.9	3.67	177.4	87.8	2.12	80.4	75.9	1.06
Average			3.03			2.80			2.70			1.44

c.p.m. = Counts per minute.

TABLE II(*B*). RATE OF P^{32} FRACTIONS (CANCER/NORMAL). AVERAGE OF FIVE CASES WITH ESOPHAGEAL CANCER.



accumulation of P^{32} is predominant in the areas showing a higher cellular activity, in which organic phosphates, components of the cell, are synthesized in great amounts.

Specific Activity.—In brief, specific activity is defined as the ratio of uptake of P^{32} by tissues to that of the total phosphorus in the same tissues. Therefore, this value indicates the rate of the partial exchange (turnover) of phosphorus with radioactive phosphorus in tissues resulting from the administration of P^{32}. The specific activity measured in 7 cases with cancer of the esophagus was 3.6 times normal, and in 10 cases with cancer of the stomach the increase of concentration of P^{32} in the cancerous tissue was 2.8 times that in the normal portions of stomach. These findings definitely indicate the more active metabolism of phosphorus in malignant tissues than in normal tissues.

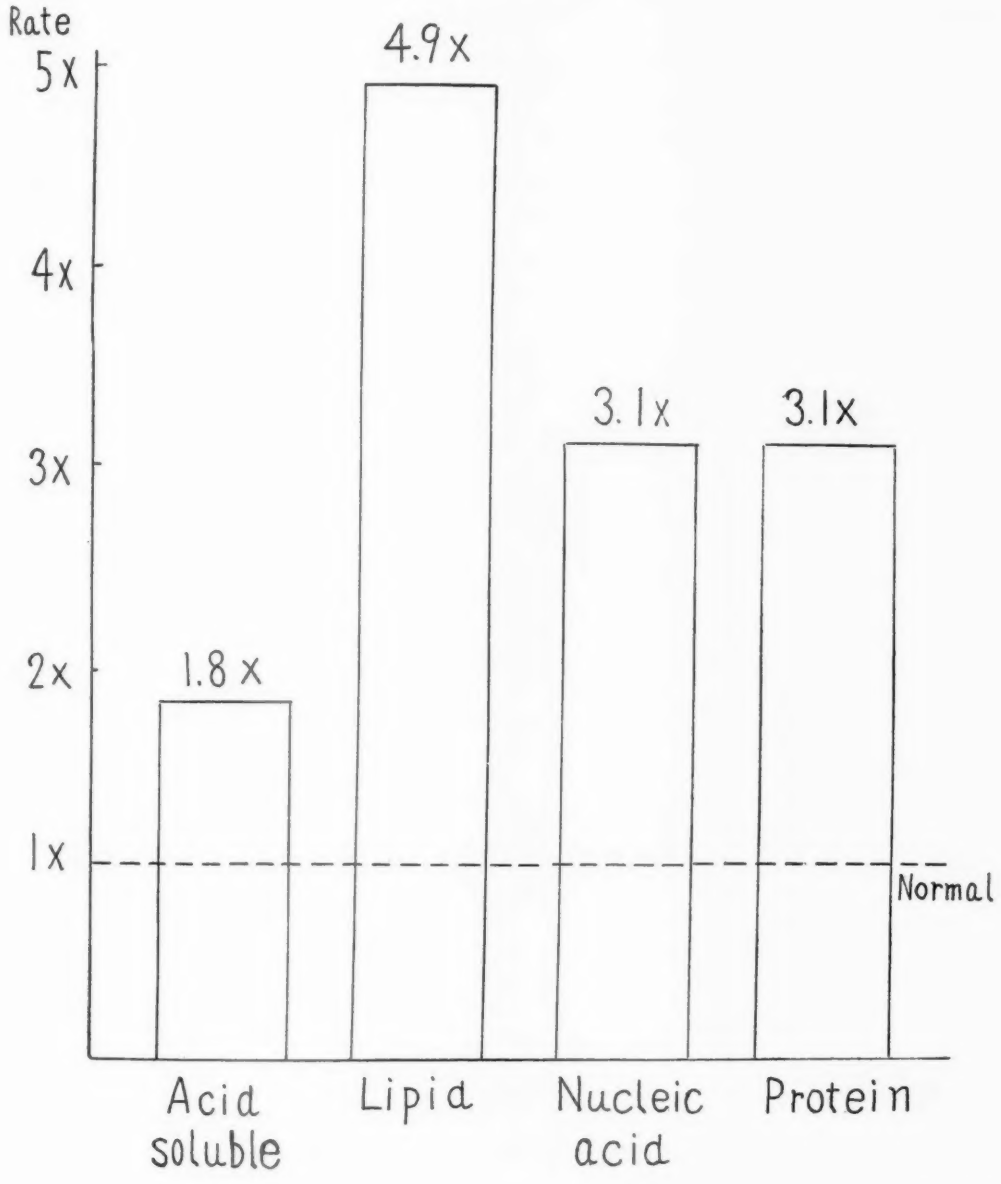
HISTOLOGIC INVESTIGATION

Histologic study was done in order to prove precisely the determining factors of the higher count over malignant areas. The conclusion is that the following three conditions were found to be the important determining factors from the histologic point of view. They are: (1) higher immaturity of cancerous cells, (2) higher density of cancerous cells, (3) absence of overlying

TABLE III(*A*). P^{32} FRACTIONS (8 CASES OF GASTRIC CARCINOMA)

NO. OF CASE	ACID SOLUBLE P^{32}			LIPID P^{32}			NUCLEIC ACID P^{32}			PROTEIN P^{32}		
	CANCER C.P.M./ GR.	NORMAL C.P.M./ GR.	RATIO CANCER/ NORMAL	CANCER C.P.M./ GR.	NORMAL C.P.M./ GR.	RATIO CANCER/ NORMAL	CANCER C.P.M./ GR.	NORMAL C.P.M./ GR.	RATIO CANCER/ NORMAL	CANCER C.P.M./ GR.	NORMAL C.P.M./ GR.	RATIO CANCER/ NORMAL
1	707	296	2.4	595	131	4.5	967	253	3.8	268	63	4.3
2	1983	1143	1.7	382	74	5.2	208	74	2.8	272	122	2.2
3	266	164	1.8	341	74	4.6	610	270	2.3	160	71	2.3
4	523	321	1.6	324	78	4.2	274	92	3.0	103	38	2.7
5	1132	557	2.0	724	138	5.2	574	182	3.2	371	113	3.3
6	984	473	2.1	276	63	4.4	334	79	4.2	213	73	2.9
7	252	198	1.3	189	32	5.9	189	73	2.6	184	57	3.2
8	316	174	1.8	257	53	4.9	237	84	2.8	237	65	3.6
Average			1.8			4.9			3.1			3.1

TABLE III(*B*). RATE OF P^{32} FRACTIONS (CANCER/NORMAL). AVERAGE OF EIGHT CASES WITH GASTRIC CANCER.



tissues on the surface of cancers. Though malignant tumors, in general, yield a fairly high counting rate, the highest counts are obtainable when malignant tissues occupy a wide space and cancerous cells contained in cancerous alveoli are more crowded and of higher immaturity. On the contrary, the lowest counts are produced when overlying tissues such as necrotic flaps are attached on the surface of a tumor, connective tissues are abundant, and cancerous cells fewer. As a matter of fact, the portion, rich with cancer pearls in squamous-cell carcinoma and the portion with larger cancerous alveoli in

columnar-cell carcinoma produce a somewhat lower counting rate than the portions, poor with cancer pearls in the former carcinoma, or with smaller cancerous alveoli in the latter.

The histologic difference of tumors such as squamous-cell carcinoma, adenocarcinoma or carcinoma simplex, and so forth, does not determine the counting rate, but rather the rate of growth and the grade of activity of the tumors are the important factors in determining counting rate. The early tumor, the chief subject of this study, shows marked growth in general. Therefore, its recognition by this method would appear to have a rational basis.

Fig. 1.

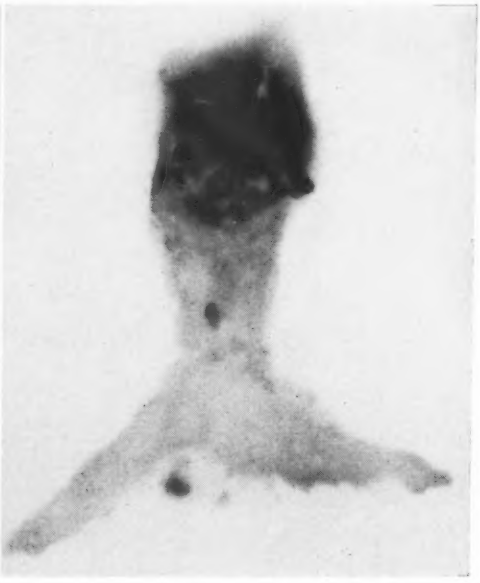


Fig. 2.

Fig. 1.—Specimen of esophageal cancer.
Fig. 2.—Macroautoradiogram of esophageal cancer.

The Relationship of Inflammation to the Count.—For a long time we have been acquainted with the fact that the uptake of radioactive phosphorus by inflammatory areas is somewhat higher than normal. The maximum deposit of P^{32} in inflammatory areas takes place during the acute stage, at which time exclusion from malignant lesions is unnecessary, as a matter of practice. We need to exclude chronic inflammation from malignant lesions in the alimentary tract. Various portions of the removed specimen, such as inflammatory, ulcerative, and cancerous areas were measured with the Geiger-Müller counter. The counting rate of the chronic inflammatory areas remained less than 1.3 times the normal count, even in the stomach where the degree of inflammation may be severe. With this criterion, inflammatory areas are easily differentiated from malignant lesions.

RADIOAUTOGRAPHY

Macroradioautography.—The macroradioautograph of the removed specimen is another worth-while method for demonstrating the selective uptake of radioactive phosphorus by tumor tissues. For these studies freshly removed specimens, which were obtained from the patients six to forty-eight hours after administration of approximately 500 μc of P^{32}, were used. After being cut, the removed specimen was spread and attached tightly onto an x-ray film, which had been previously covered with a very thin polyethylene sack (0.01 cm. thick) to prevent the film from becoming wet, and kept for about seventy-two hours below 4° C. in the refrigerator. After completing

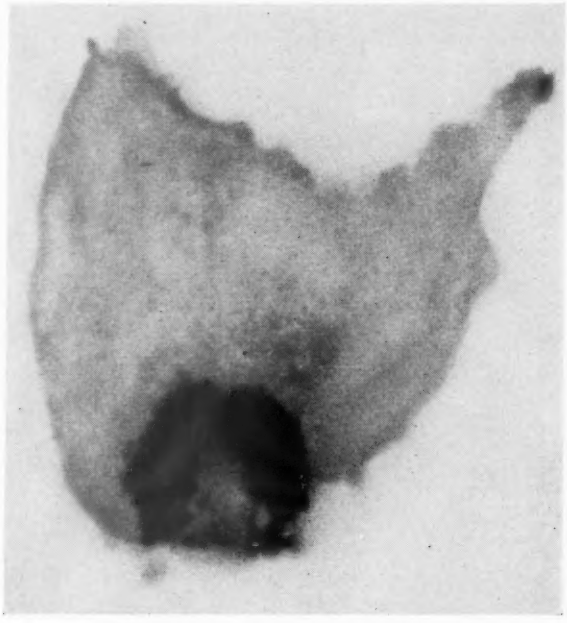


Fig. 3.—Macroautoradiogram of gastric cancer.

these procedures, the film was developed and the macroradioautograph obtained. Fig. 1 indicates the specimen of a cancer of the esophagus. Fig. 2 shows its radioautograph, in which a heavy deposit of silver is seen corresponding to the amount of P^{32} in the malignant tissue. A tiny black spot in the lower portion of this picture indicates a submucosal metastasis which was not identified by the naked eye. Microscopic study of these black zones was done to measure the silver particles on the radioautograph, revealing that the distribution of silver particles was strikingly parallel to the count of the Geiger-Müller counter. In cancer of the stomach, the density of silver particles on the radioautograph was 3 times normal. The same rule holds good in cancer of the ileocecal region and the rectum. Figs. 3 to 5 indicate the radioautographs of gastric, ileocecal, and rectal cancers, respectively.

The local variation in the count measured was investigated for the normal mucosa of the esophagus, in the upper, middle, and lower segments. It was found that there was only a 4 per cent local variation in the count over

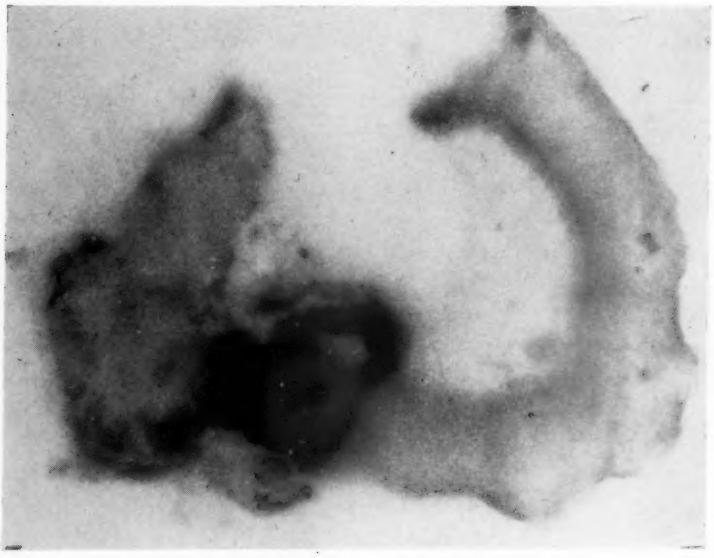


Fig. 4.—Macroautoradiogram of ileocecal cancer.

Fig. 5.—Macroautoradiogram of rectal cancer.

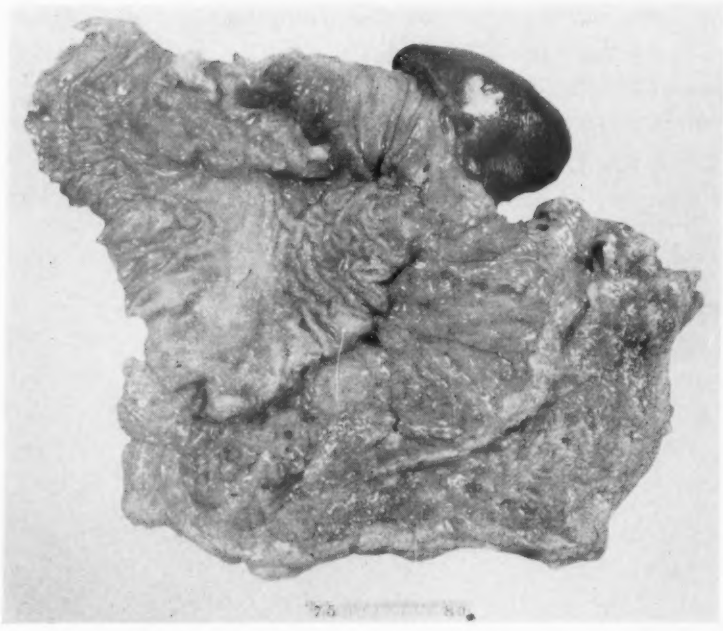


Fig. 6.—Specimen of cardiac cancer. Total gastrectomy combined with resection of the spleen and the tail of the pancreas.

Fig. 7.—Macroautoradiogram of the specimen.

the normal mucosa of the esophagus, well within the limits of "probable error." Therefore, one may assume that the count obtained at optional areas of the esophageal mucosa is equivalent to the mean count of the whole esophageal mucosa. The same holds true in the stomach, because local variation in the count over the normal gastric mucosa remains within 5 per cent.

Figs. 6 and 7 are the removed specimen of a cardiac cancer with cancerous invasion of the pancreas, in which pancreatosplenectomy was performed, and its radioautograph.

On the radioautograph, the malignant area of the cardia is depicted as a black zone, but neither the spleen nor the pancreas is identified. As a matter of fact, a low per cent of irradiation is picked up by the Geiger-Müller counter, when the entire wall of the esophagus or the removed stomach is placed between the counter and this radioactive substance. This is undoubtedly attributable to the fact that the principle of this diagnostic method

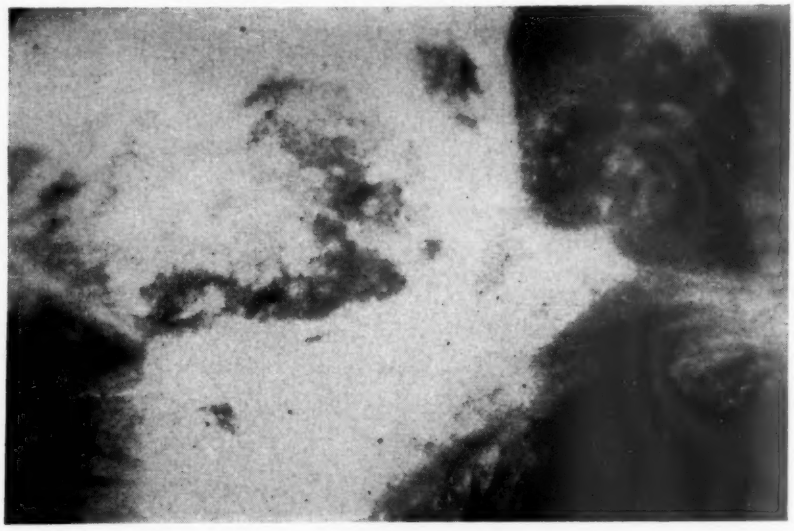


Fig. 8.—Microautoradiogram of gastric cancer (black zone indicates cancerous alveoli).

is wholly based upon the beta-ray emitting properties of radioactive phosphorus. Therefore, it is quite in the nature of things that the film was little exposed to irradiation from those adjacent organs, located external to the alimentary tract. On the other hand, when the counting was done for radioactive substances interposed in the submucosal layer of the esophagus or the stomach, 80 per cent of irradiation was caught by the Geiger-Müller counter. This is fully available for determination of cancerous infiltration or metastases to the submucosal layer, as is readily shown in the radioautographs of the esophagus.

Microradioautography.—In order to show in microscopic measure where the selective uptake of radioactive phosphorus occurs in malignant tissues, microradioautographs were taken. Six to forty-eight hours after intramuscular injection of P^{32} (5 to 10 μc per Kg., that is, 300 or 500 μc in total) the specimen

was removed from the patient and fixed in a 90 per cent formalin alcohol solution, dehydrated rapidly by means of dioxane, and then inlaid into paraffin. The material thus obtained was cut into 5 or 10 μ-thick slices. Each slice was attached to a slide glass, and covered with stripping film* in water. After desiccating, they were preserved for one or two months at 1 to 4° C. in the refrigerator. Finally, they were developed with FD-111. Fig. 8 reveals black zones depicting the location of cancerous alveoli and also white discolored zones as the location of interstitial connective tissues. This study is quite useful in corroborating this characteristic feature of malignant cells, i.e., the selective uptake of radioactive phosphorus.

Fig. 9.

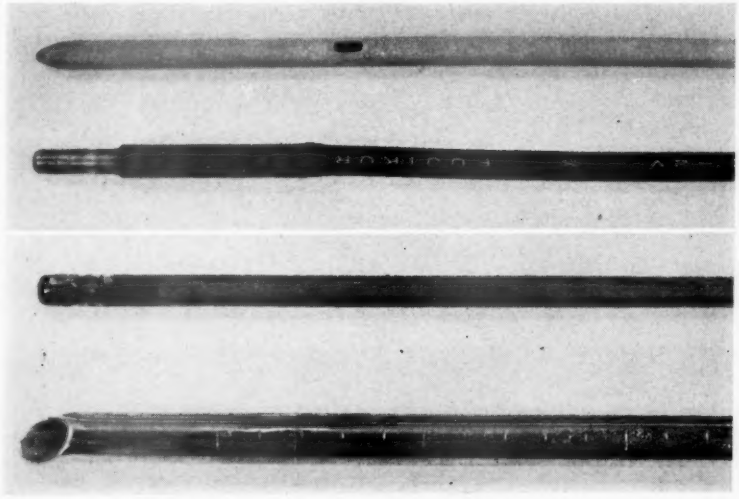


Fig. 10.

Fig. 9.—The Geiger-Müller tube for the esophagus (Type I).
Fig. 10.—The Geiger-Müller tube for the esophagus (Type II).

CLINICAL APPLICATION

Dosage and Time for the Counting Examination.—Radioactive phosphorus, orthophosphate in dilute hydrochloric acid, obtained from the Radiochemical Center, Amersham, England, was diluted in a sterile isotonic solution of sodium chloride, and 5 to 10 μc per Kg., a total of 300 to 500 μc of P^{32} was administered intramuscularly.

Six to forty-eight hours after the injection of P^{32} was the optimal time for the subsequent examination with the small Geiger-Müller counter.

The Geiger-Müller Counter for the Alimentary Tract.—The small Geiger-Müller counter for alimentary tract examination was made by the Scientific Research Institute, Bunkyo-Ku, Tokyo, and has the following efficiencies:

Plateau	100 v.
Slope	2.5 per cent/100 v.
Background	2 to 3 c.p.m.

*Fuji Stripping Film for Microradioautograph.

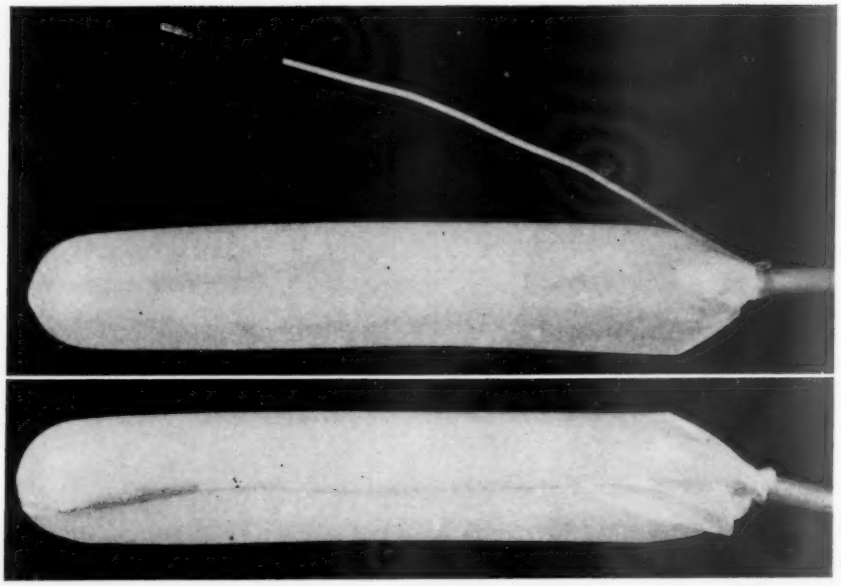


Fig. 11.—The Geiger-Müller tube for the stomach. The tube is wrapped with a rubber balloon as shown here before measuring (Type I).

Fig. 12.

Fig. 13.

Fig. 12.—The Geiger-Müller tube placed on the lesser curvature of the pyloric portion (roentgenogram).

Fig. 13.—The Geiger-Müller tube placed on the lesser curvature of the cardiac portion (roentgenogram).

The Geiger-Müller counter for the esophagus: The Geiger-Müller counter used for exploration of the esophagus (Fig. 9) was a tube 5 mm. in diameter and 20 mm. in length, a size suitable for passage through the lumen of the esophagus. Its connection was a cable of nasal catheter size, quite soft and easily flexible, which was capable of being introduced orally with little difficulty. At first, the Geiger-Müller counter was introduced into the cardiac portion of the stomach, and then, while extracting gradually, counts per minute were measured.

In order to detect minute findings in the esophagus, this Geiger-Müller tube was introduced under direct vision through the esophagoscope as illustrated in Fig. 10. This Geiger-Müller counter was shielded completely from beta-ray emission from the surroundings by a thin copper cover having a fenestella, 5 mm. in diameter, near the tip, so that only beta rays entering through this fenestella were permitted to reach the counter. Accordingly, the counting measurement in the esophagus is done quite selectively at any optional small area.

The Geiger-Müller counter for the stomach: The Geiger-Müller counter for this purpose was somewhat smaller than that for the esophagus. The counting in the stomach was done under fluoroscopic examination. This manipulation was facilitated by keeping the stomach distended with a balloon filled with air (Figs. 11 to 13). Thus, the count was obtained at any optional region of the stomach.

It was important to approximate the Geiger-Müller counter to the suspicious portion of the wall of the alimentary tract. For this reason balloons were employed.

Counting Measurement in the Esophagus and the Cardia.—This diagnostic technique has been employed upon a total of 75 cases with lesions of the esophagus and the cardia. Of these, 58 cases were malignant lesions, including 39 esophageal cancers, 18 cardiac cancers, and 1 esophageal sarcoma. The counting rates in this series, within a range of 3.6 times, the maximum, to 1.3 times, the minimum, were sufficient to exclude them from nonmalignant lesions. On the other hand, the count measured in 17 cases with benign lesions remained within the normal limits without any exception. Several interesting cases will be presented below.

Early cancer of the esophagus: This case was an early cancer of the esophagus. Preoperative roentgenologic study showed disorders in the rugae of the esophageal mucosa, and radioactive study uncovered an area which gave 2.3 times the normal count. It was found later that this lesion was no larger than the tip of a little finger. Palpation failed to disclose its presence at operation, and cancerous invasion did not extend beyond the inner annular musculature of the esophagus. Figs. 14 to 16 show the removed specimen, macroautograph, and microscopic section. The fact that such a tiny tumor yielded 2.3 times the normal count is evidence of enhanced intracellular activity in an early malignant tumor, and is also indicative of a definite advantage of this method over conventional methods.

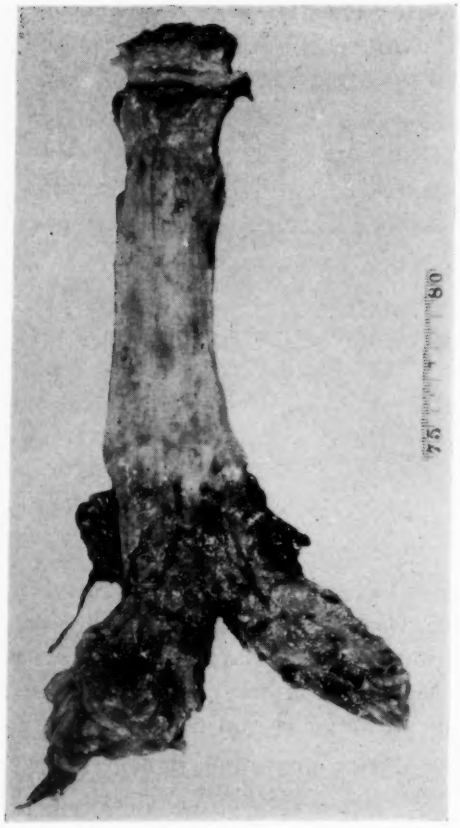


Fig. 14.

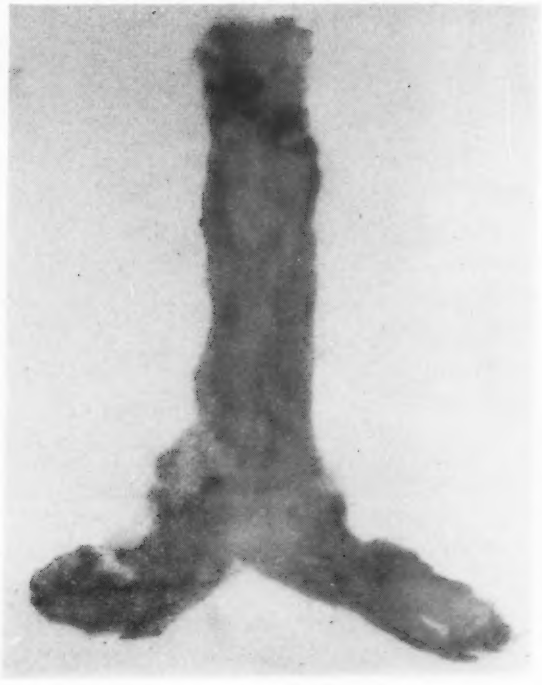


Fig. 15.

Fig. 14.—Specimen of early esophageal cancer.
Fig. 15.—Macroautoradiogram.

Fig. 16.—Microscopic structure of the removed specimen. Cancerous invasion does not extend beyond the musculature.

Sarcoma of the esophagus: One of the rare malignant lesions of the gullet which was explored was a sarcoma of the esophagus. In the radioactive study of this case, the count suggested a 6 cm.-long malignant area, extending from 29 cm. to 35 cm. below the gingival border. This segment yielded about twice the normal count. The removed specimen revealed a sarcoma of the esophagus which was covered with an almost intact mucosa (Fig. 17). It was found from this study that lesions covered with mucous membrane do not keep malignancy concealed from this diagnostic weapon.

Cancer of the cardia with submucous infiltration of the esophagus: This case had been considered a cancer of the cardia in the preoperative roentgenologic study. Nevertheless, radioactive study gave a higher count over the area extending from 36 cm. to 45 cm. below the gingival border, obviously suggesting the necessity for intrathoracic manipulation as well as abdominal operation. The removed specimen proved that submucous cancerous infiltration corresponded exactly to the area which yielded the enormously high counting rate in preoperative study (Fig. 18).

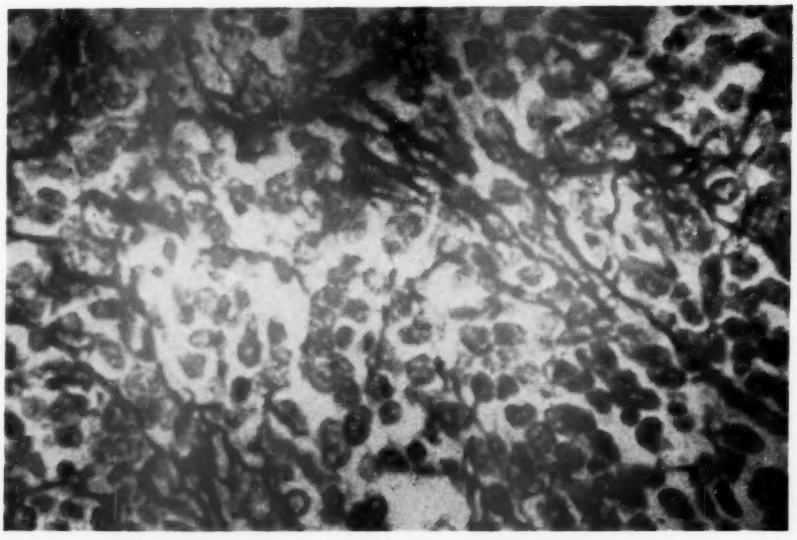


Fig. 17.—Round-cell sarcoma of the esophagus.

Differential diagnosis: Heretofore it has often been difficult to exclude benign lesions or functional disorders, such as esophageal neurosis, esophageal or cardiac spasm, compressive esophageal stricture, and others, from early malignant lesions in the esophagus. This difficulty, however, has now been completely removed by an easy examination with radioactive phosphorus, because the counting rates of these benign lesions always remained within normal limits.

Benign tumor: This is an example of a benign tumor which portrayed a shadow defect in the x-ray study, but did not yield an abnormal count in the radioactive study. Accordingly, we have continued observations periodically, without surgical treatment, for a period of two years and have failed to find any malignant sign, such as enlargement of the tumor and so forth.

Counting Measurement of the Stomach.—Ninety patients with gastric disease submitted to this examination. Of these, cancer of the stomach was found in 60 cases, the counting rates of which ranged between the maximum rate of 5.7 times normal, and minimum rate of 1.6 times normal with the exception of two cases: a carcinoma simplex and a mucinous carcinoma. On the other hand, the count of benign tumors remained within normal limits. A few interesting cases will be presented below.

Early cancer of the stomach: This patient had an early, thumb-sized tumor of the pyloric region of the lesser curvature which was not identified by preoperative roentgenologic study. Nevertheless, the counting rate was 1.8 times normal, sufficient for positive diagnosis of cancer of the pylorus.

Fig. 18.—Submucosal cancerous infiltration of the esophagus from the cardia.

Ulcer of the stomach: This case presented a small, finger-tip-sized niche in the body of the stomach near the lesser curvature on x-ray study, which indicated an ordinary ulcer of the stomach. The radioactive study detected a small portion of the surrounding margin of the ulcer which yielded the high count of 1.6 times normal. The radioautograph of the removed specimen presented a black spot at the border of the ulcer as seen in Fig. 19. Malignant changes were confirmed by histologic study of this suspected area (Fig. 20). Heretofore, preoperative evaluation of a cancer which has its origin in an ulcer has

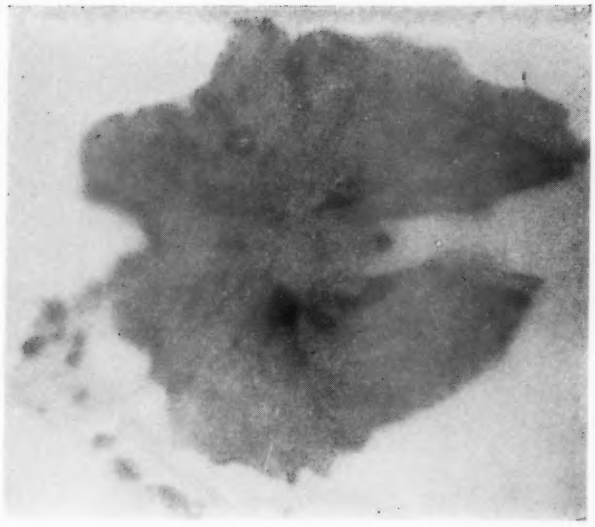


Fig. 19.—Macroautoradiogram of gastric ulcer with malignant changes. The black zone indicates the location of malignant changes.

Fig. 20.—Carcinoma simplex is seen in a small portion of marginal border of the ulcer.

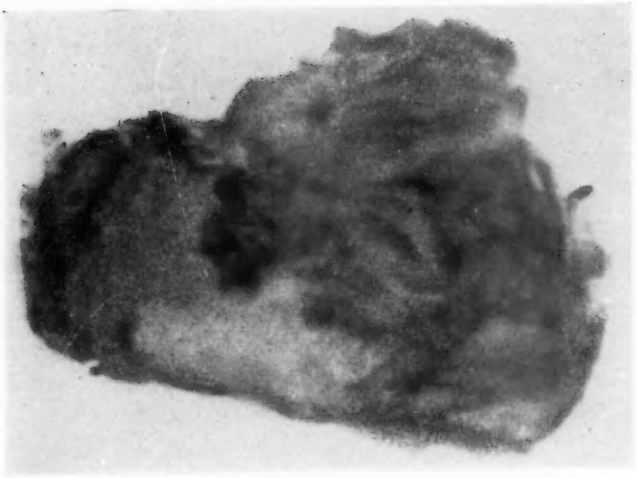


Fig. 21.—Macroautoradiogram of gastric adenoma with malignant changes. Only the black spots indicate the location of malignant changes.

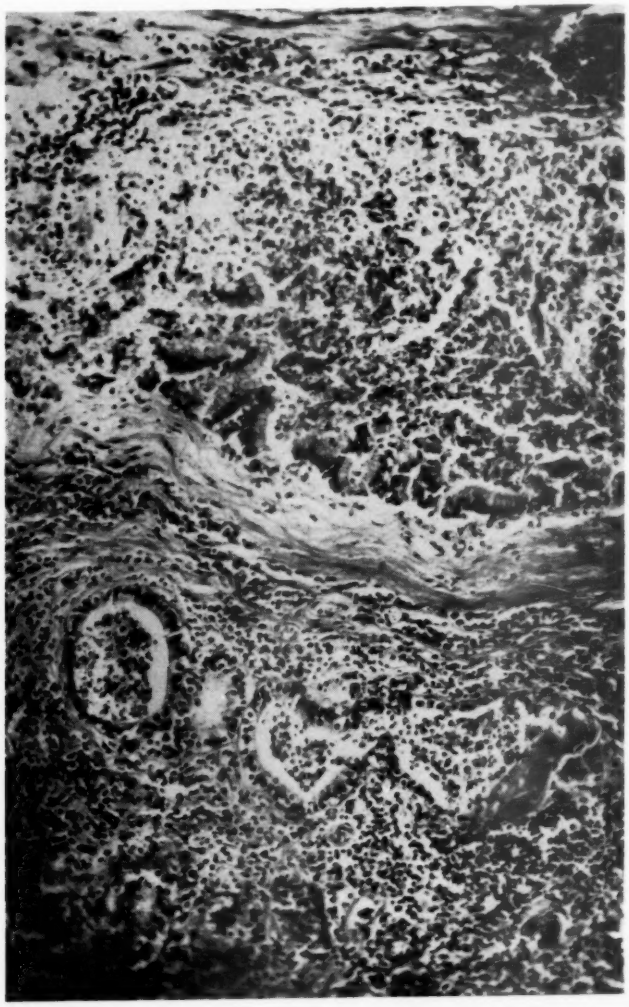


Fig. 22.—Microscopic structure of adenoma with malignant changes. The upper portion is the malignant area.

been considered nearly impossible. This difficulty, however, is immediately solved when we resort to the radioactive study. This is a noteworthy feature of this diagnostic technique.

Adenoma with malignant changes: This patient's preoperative roentgenogram revealed a shadow defect resembling gastric cancer, while his radioactive study detected a small portion of the tumor which yielded 1.8 times the normal count, obviously different from the findings in his x-ray picture. The radioautograph of the specimen (Fig. 21) presented a tiny marked black spot which made a contrast to the gray area of the remainder of the tumor. Histologic study corroborated malignant changes taking place in this small portion of the tumor (Fig. 22). Thus, a benign tumor or ulcer of the stomach, even though apt to undergo malignant degeneration, may be differentiated from frank malignancy.

Cyst of the stomach: This case revealed a round shadow defect at the pyloric area, but the radioactive study did not show an abnormal count. The radioautograph did not present black zones, which was consistent with the count measured. Histologic study revealed the lesion to be a cyst of the stomach associated with chronic inflammation.

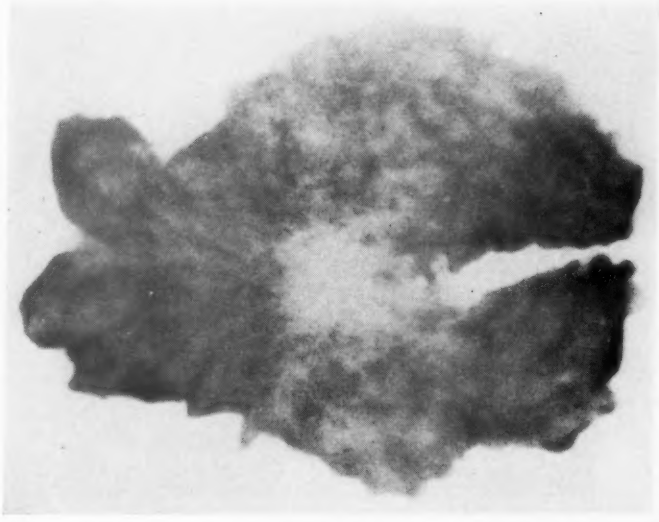


Fig. 23.—Macroautoradiogram of gastric ulcer. Discolored area indicates the location of the ulcer.

Ulcer of the stomach: This patient's roentgenogram revealed a fairly large niche located along the lesser curvature. The counting measurement disclosed a portion, 1 cm. long, with a lesser count. The removed specimen demonstrated stiff cicatricial tissues surrounding the ulcer and the autograph showed a circular discolored area corresponding to the cicatricial zone (Fig. 23).

Cancer of the pancreas: In this case, diagnosis by x-ray study differed from that by radioactive study. The preoperative roentgenogram (Fig. 24) was strongly suggestive of abnormalities in the upper part of the lesser curvature, while radioactive study gave no abnormal count. He submitted to laparotomy,

which disclosed a cancer of the pancreas. No abnormality was found in the stomach itself. Splenopancreatectomy was performed. Thus, this study is useful in confirming normal findings in the mucous membrane and neighboring layers of the gastric wall.

Counting Measurement in the Rectum.—Cancer of the rectum is another disease to which this method is applicable. In cancers of the sigmoid in which x-ray study has failed to detect a lesion and in which the proctoscope was not sufficiently inserted to visualize the lesions, the Geiger-Müller counter displays its competent ability to indicate malignancy. Of 6 cases with rectal cancer who submitted to the study, 5 cases presented a high count, ranging from 3.2 to 2.2 times normal. The one exception yielded a lower count due to marked mucinous degeneration.

Fig. 24.—Roentgenogram of cancer of the body of the pancreas. This picture suggested cancer of the lesser curvature of the body of the stomach.

Application to Exploration of the Nodes Involved During Operation.—An attempt has been made to explore lymph node involvement by means of this method during operation. This investigation was used in a study of 244 regional lymph nodes. The study included 10 cardiac cancers, 14 gastric cancers, 2 ileocecal cancers, and 4 rectal cancers. It was noted in this series that there were 114 nodes involved with cancer among a total of 224 nodes, and that, out of these 114 nodes involved, 110 nodes, or 97 per cent, showed 1.2 times or more the normal count. In the light of this fact, one may assume that complete removal of nodes producing a count of 1.2 times normal, or more,

probably leaves few metastases in the surveyed regions. Moreover, cancerous invasion of the nodes initially takes place in the vasa afferentia and proliferation of the cancerous cells taking root occurs in the peripheral sinuses, located near the surface of the nodes. Therefore, detection of the nodes involved is feasible. The actual count on the lymph nodes involved revealed 1.7 times normal in 79 per cent of 90 nodes explored.

Thus, this technique supplies us with valuable information for selecting an operative method for radical treatment of cancer. It is especially valuable in cancer originating in ulcer. In this instance, the counting measurement over regional lymph node sites for involvement affords a criterion on which it is decided whether total gastrectomy or cardiectomy is the procedure of choice.

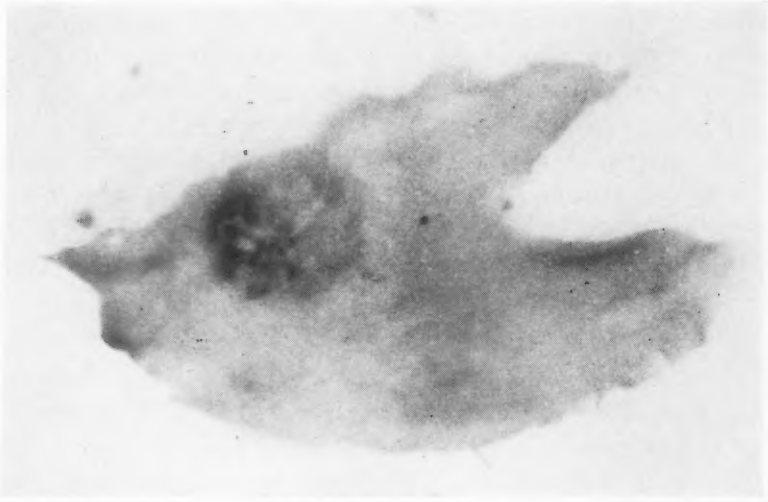


Fig. 25.—Macroautoradiogram of gastric carcinoma. Histologic study revealed that adenocarcinoma converted partially to mucinous carcinoma. The heavy black zone indicates the adenocarcinoma, and the light black zone indicates the area in which mucinous degeneration occurred.

Furthermore, it is often difficult to distinguish cancer of the ileocecal region from ileocecal tuberculosis, because age distribution and local findings are often the same. Since the mode of removal of the lymph nodes is different in both situations, their differentiation is quite important. Here radioactive study shows a much higher count in cancer, and a normal count in tuberculosis, permitting us to differentiate between the two diseases.

Errors in Diagnosis.—There are some carcinomas in the alimentary tract which do not yield a high count. One of these is mucinous carcinoma. In carcinoma of this type, degenerative changes are often pronounced, and the metabolism of phosphorus is markedly reduced. Less phosphorus is retained in the tissues, and the counting rate drops. However, this does not mean detection of mucinous carcinoma is impossible by use of this method. In the radioautograph of the gastric cancer shown in Fig. 25, the heavy black zone indicates a portion where columnar cell carcinoma remains alive, and the light black zone indicates a portion where degenerative changes have taken place. In the majority of

mucinous carcinomas there are some portions which are free of degeneration. The primary subject of this study is the early malignant lesion, and those tumors with great degenerative changes are not suitable for this study.

Another tumor often producing low counts is the scirrhous carcinoma, in which a marked production of connective tissue is the rule. Therefore, special care should be paid to such tumors as mucinous or scirrhous carcinoma. Fortunately these are relatively infrequent. There are often some portions where adenomatous or columnar cell tissues still survive and yield a fairly high count. In the examination of such lesions it is important to survey carefully the entire tumor so as not to overlook a more active portion. Of 5 mucinous carcinomas and 4 scirrhous carcinomas of the stomach examined, only one case of each type showed less than 1.5 times the normal count.

Reliability of This Diagnostic Aid.—The reliability of this diagnostic technique in lesions of the esophagus and the cardia was 100 per cent in 58 cases with malignant lesions and 19 cases with benign lesions. Ninety human subjects with disease of the gastrointestinal tract other than of the gullet and the cardia revealed a normal count in both regions. The reliability in lesions of the stomach was 97 per cent in 61 cases with malignant lesions, and 100 per cent in 29 cases with benign lesions. Seventy persons with disease of the gastrointestinal tract other than of the stomach revealed a normal count of this organ.

CONCLUSIONS

A study of the diagnostic significance of radioactive phosphorus in early cancer of the alimentary tract has been presented with its basic research and clinical application. In brief, characteristics of this diagnostic method are: (1) The principle of this method reflects a biochemical feature of neoplasms, in contrast to those conventional methods which are exclusively based upon the morphologic features of neoplasms. Accordingly, the most suitable subjects for this method are the early growing tumors, rather than large tumors in which degenerative or necrotic portions are present. (2) The interpretation of this method is based upon the count or the tracing, precise mechanical processes eliminating the personal equation.

As emphasized above, this diagnostic method supplies us with quite specific information, not obtainable by using other forms of examination. Intelligent execution of this method in combination with conventional methods, such as x-ray study, endoscopic study, and smear and other tests, permits us to obtain a much more accurate diagnosis of cancer in the alimentary tract.

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RESULTS OF SURGERY IN CARCINOMA OF THE STOMACH DISCOVERED BY PERIODIC ROENTGEN EXAMINATION

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INTRODUCTION

THE detection of gastric cancer at a time when it is possible to extirpate it surgically remains one of today's major medical problems. In less than half of the cases which are diagnosed is it possible to even attempt a curative operation. Recent reports show five-year survival rates varying from a low of two per cent to a high of 14 per cent, but the majority of figures reported are between four and nine per cent.[2, 16, 17, 24] Such results emphasize the very poor prognosis and the great need for improvement in one or all of the three areas of prevention, detection and treatment.

Efforts at the detection of gastric cancer have been made in a variety of ways.[7, 20, 22] Proposals to examine gastric secretions for tumor cells, proposals for routine gastroscopy, and many other procedures have been found impractical for use on a large scale. While gastric cytology and gastroscopy may be effective means for the identification of the nature of a gastric lesion their use as a means of detection of a lesion in the stomach has not been successful. The only feasible method generally applicable and reasonably accurate is by means of x-ray examination. But there are many difficulties in this method, chief of which is its expensive character in terms of personnel, as well as time and material. Such economic deterrents cannot be treated lightly. Kirklin[12] proposed that an adequate detection program would entail examining every person 40 years of age or over every three months. From this he concluded that any program for the routine detection of gastric cancer in symptomless individuals was impracticable in the light of the number of trained radiologists available and the personnel needed for such a program. In addition, there are serious problems of patients' acceptance.

It is imperative, therefore, that some compromise to such an ideal program be accepted if any progress is to be made. A great deal of effort has gone into simplifying the ordinary roentgen examination of the stomach. Photofluorography, while not completely evaluated, holds some promise as a screening device.[8, 20, 30] The use of fluoroscopic examination alone has been tried but not completely evaluated and there are grave doubts as to its effectiveness.[22] Attempts to screen large groups of individuals in order to select those who are considered to have precursors of carcinoma of the stomach have been reported by State and associates[23] and Wangensteen and asso-

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ciates.[28] One of us has reported[18, 19] on the results of periodic roentgen examinations of the stomach in patients with pernicious anemia and in symptomless individuals selected from the general population on the basis of their low gastric acidity. The most recent report[11] on the value of achlorhydria as a screening device for the detection of gastric cancer is most encouraging. A serologic test as a screen device has been searched for but without success to this date. The possibility of extending the interval much beyond the three months' period, suggested by Kirklin,[12] was thought worthy of investigation. It should be noted that in the previous periodic examinations reported by State[23] and by one of us,[19] a six months' period was considered adequate.

The question also has been raised repeatedly as to whether the early diagnosis of a small lesion by roentgen examination would be of any real salvage value. It is widely held that there is a biologic predeterminism which precludes cure in almost all cases of gastric malignancy regardless of the size of the lesion itself. This view was recently presented by MacDonald and Kotin[15] who claim that 80 per cent of all gastric cancers are "biologically uncontrollable." There is relatively little evidence in the literature which bears cogently on this matter. Recently a paper by Comfort and his associates[5] presented evidence strongly contradictory to this thesis. They found a much higher five-year cure rate in carcinomas of the stomach of less than 4 cm. in diameter than in larger tumors. Furthermore, the cure rate improved steadily in inverse ratio to the size of the lesion down to a one-centimeter level. It is fair to ask whether a small lesion or one detected before symptoms is really an early lesion. Would surgery in relatively symptomless individuals with relatively small lesions be more successful than the present results in symptomatic patients? This study was undertaken in an attempt to clarify some of these questions.

MATERIAL STUDIED

During the years 1939 through 1950, 21,738 patients had one or more upper gastrointestinal tract examinations at the University of Minnesota Hospitals. From this series, those patients who developed carcinoma of the stomach, either during those 12 years or subsequently, were studied. From such patients, known to have had carcinoma, a subgroup was selected on the following basis: all cases in which on one occasion a roentgen examination of the stomach had been reported as indicating either the presence of a nonmalignant condition or a completely negative situation and at a later date a repeat examination had led to a final diagnosis of gastric cancer. It seems reasonable to assume that a lesion not detected on one examination but found on later studies was either extremely small on the very first occasion and grew in size subsequently, or was not present at all and thus appeared for the first time while under observation. Such a succession of events would, in effect, simulate a periodic survey. It would be difficult to obtain a better group in which the lesions are really small or at an early stage in their development. While the final diagnosis was ordinarily established by means of the roentgen examination, in a few instances a definitive diagnosis was not fully clear until tissue removed at surgery was examined. Seventy-eight cases were found which fulfilled the criteria described above.

RESULTS

Within the group of 78 cases selected, there were found 21 patients in whom the repeated roentgen examinations of the stomach had been made at

intervals of less than six months. A review of all the roentgenograms in this sub-group indicated that there had been little significant change in the roentgen manifestations of the cancer on the two examinations; the problem actually lay in recognizing and interpreting such changes. For example, in 7 of the cases the delay in making the correct diagnosis resulted from the difficulty in distinguishing benign from malignant lesions; in 5 the lesion was an ulcer, in 2 it was a polypoid tumor. There were 6 cases in this group in which the lesion was in the fundus of the stomach and was apparently missed on the first examination. Persistent dysphagia was usually responsible for repeated examination, at which time the correct nature of the process was identified. The high percentage of cases with carcinoma of the fundus in this group emphasizes the difficulty in the diagnosis of such lesions even in symptomatic patients. The median interval between examinations in this sub-group is only one month; the average interval was 1.7 months. In 10 the lesion was resectable and in 5 there was no evidence of lymph node involvement on microscopic examination.

It is clear that this sub-group is not an example of cancer detection by periodic examination but rather a failure in the roentgen method. The fact that there was no appreciable change in the roentgen findings indicates that the cases were not necessarily early or in the beginning of their development. For this reason this sub-group was excluded from further consideration. It is interesting to observe, however, that a group of cases re-examined at less than six-month intervals showed so little change. Our whole experience points in this direction, namely, that repeated examination at less than six-month intervals is not at all imperative.

It was found that in 18 of the remaining 57 cases the interval between roentgen examinations was greater than four years. While on occasion gastric cancer may remain indolent over a long period of time, we felt it advisable to exclude such cases also. Clearly more than a four-year interval between examinations is of little practical value.

There remained 39 cases in which the interval between examinations varied from six to forty-eight months. The median interval was fourteen months; the average interval was nineteen months. There were 25 men and 14 women in this group; the median age was 71.

All roentgen examinations on these patients consisted of fluoroscopy, spot films made during fluoroscopy, and a series of routine roentgenograms. It must be noted that the examinations were done by a wide variety of radiologists, the majority of whom were residents in training. In most cases the films were also viewed by a graduate radiologist, but the major burden of the diagnosis rested upon the resident.

The patients under consideration fell into three classifications. Nineteen were clinic patients who had many specific symptoms for which roentgen examination of the stomach was requested. Fourteen could be classified as

being within a group which was selected because of presumed susceptibility to gastric cancer. They were all patients 50 years of age or older who had less than 30 degrees of free acid on gastric analysis after triple histamine. These patients were relatively free of symptoms originally, that is, at the time of the first examination. All of them were examined at six to twelve-month intervals. Seven out of this group were completely asymptomatic, at least insofar as the gastrointestinal tract was concerned, even at the time of the final diagnosis. Finally, 6 of the patients were in a group going through our Cancer Detection Center who were also originally asymptomatic. Among these, the women were over 45 years of age, the males over 50. All of this group had less than 20° of free acid on gastric analysis after histamine. Thus, in 20 patients, more than one-half of the group, a definite effort was being made to detect gastric cancer by periodic examination in relatively asymptomatic individuals. In the other 19 cases, the roentgen examination was the consequence of the clinical picture presented.

In the entire group, there were 19 who had symptoms of recent origin at the time when the final diagnosis was made. Eight had symptoms of over two years' duration which were relatively unchanged. Twelve were completely asymptomatic at the time when the surgery was done.

When first seen by us, all of these patients were negative on physical examination. By the time of the operation, 6 had some positive physical finding.

Of the 39 cases, 38 had gastric acidity determined at some time during the course of their study and 27 of these (71 per cent) were achlorhydric.

At the time of the definitive diagnosis, 35 of the 39 were considered to be operable. Two of these refused surgery so that histologic proof of the diagnosis was available in 33 cases. In 28 of these a gastric resection was done. The histologic diagnosis in all cases was adenocarcinoma.

In 18 cases there was no evidence of spread to the regional lymph nodes. This represents 46 per cent of the 39 cases under consideration. If the 2 cases which refused surgery and in whom there was no possible way of determining the presence or absence of involved lymph nodes are excluded, the negative group represents almost one-half of the cases. It may be assumed that the 4 cases that were considered inoperable had lymph node spread.

The time intervals between examinations and the presence or absence of positive lymph nodes in the various groups are illustrated in Fig. 1. It is notable that the discarded groups at both ends of the time scale had the higher percentage of lymph node involvement. The lowest percentage is in the group in which the interval between examinations was less than 18 months. This distribution bears out what might be expected, for the latter group had the best chance of being discovered at an early stage.

The roentgenograms themselves were available for review in 36 of the 39 cases. In 15 there was some suggestion of a pathologic process on the first

examination; in 11 of these it was not recognized at the time of the first examination although in retrospect it appeared to be probable. In 3 of the cases the diagnosis of benign polyp and in one the diagnosis of benign ulcer were made on the first examination.

The rate of growth as observed in the roentgenogram varied considerably. One polypoid lesion remained unchanged over an eighteen-month period. A considerable increase in the size of any of the lesions in six months to a year was extremely unusual, and very moderate increases in size in one year or more were the rule.

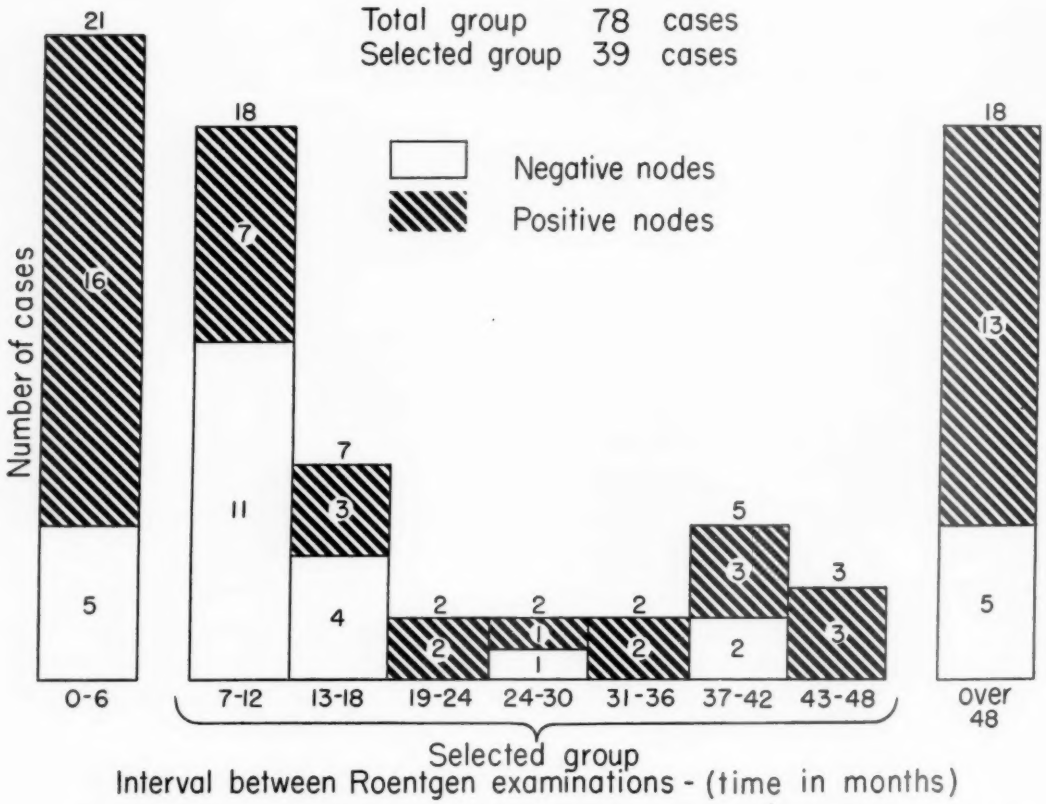

Fig. 1.—The interval between examinations in the selected group of cases and the incidence of lymph node involvement are compared. Note that the excluded groups are also shown. The preponderance of cases in which the lymph nodes were not involved is in the group in which the interval between examinations was from six to eighteen months.

A consideration of the character of the roentgen findings would indicate that there were some 20 cases of the exophytic variety, 3 ulcerative, and 16 characteristically infiltrative. However, a review of the pathology in these cases indicates that only about 15 per cent were of the polypoid type.

In 5 of the 39 cases, even the final roentgen interpretation was incorrect. It is of some interest to elaborate on these errors. The first case was erroneously diagnosed as an intramural tumor, but proved to be a polypoid carci-

noma high on the greater curvature with a central ulceration. The second was thought to be a diffuse ulcerative gastritis but proved to be a diffuse infiltrating adenocarcinoma, as proved later at autopsy. The third error of this type was the interpretation of an ulcer as being benign when, in fact, it was malignant. However, when no healing occurred after one month of medical therapy, a gastrectomy was performed. The final 2 cases were polypoid lesions thought to be benign. One of these measured 2 cm. in diameter and was on a stalk, and the other was a lesion one centimeter in diameter. It should be noted that in only one case was a nonsurgical lesion interpreted

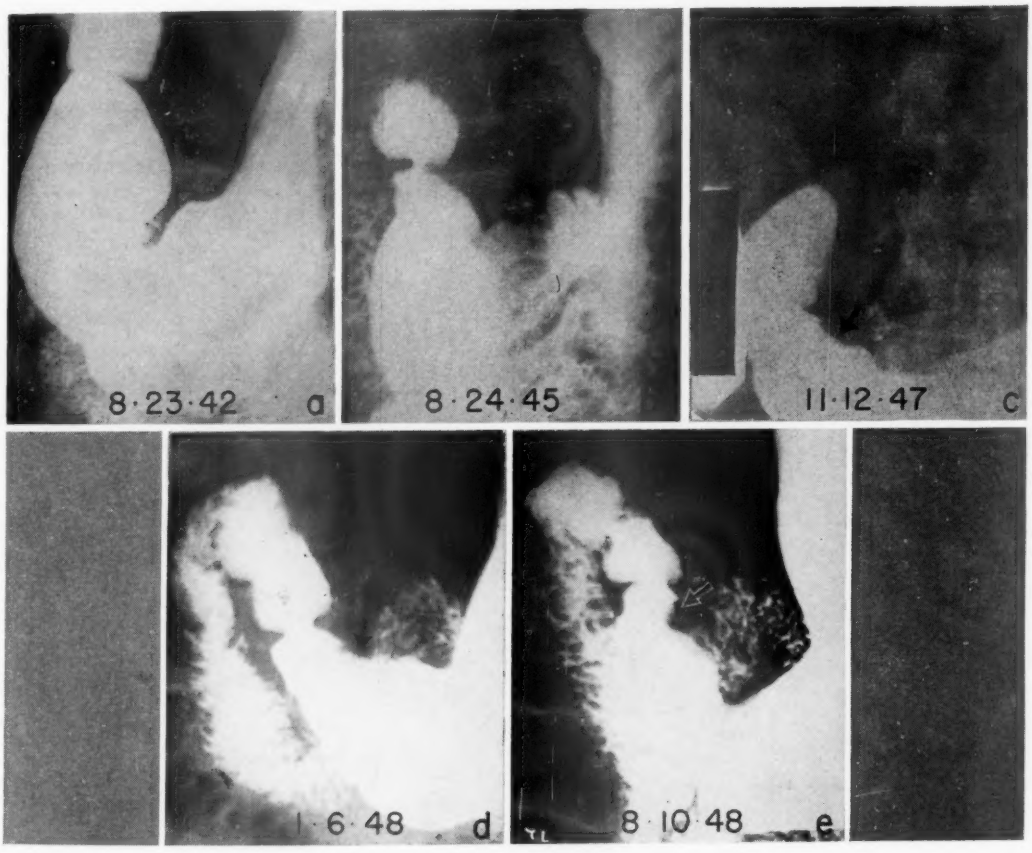

Fig. 2.—Case 1. Selected roentgenograms for comparison to show development of infiltrating carcinoma. *A*, normal. *B*, probably normal. *C*, beginning infiltration lesser curvature (arrow). *D*, Same with little change (arrow). *E*, Nine months after first evidence of abnormality shows increasing process (arrow).

amongst this group. The presence of either intramural or so-called benign tumors of the stomach is usually an indication for surgery and hence there was no real loss by reason of this error. It should be emphasized, however, that these were the errors made on the second examination, not on the first.

As illustration of the difficult problems in diagnosis which are encountered, and of the various types of cases in this group the following cases are briefly reported.

CASE REPORTS

CASE 1.—Woman, aged 71, no gastric symptoms, routine study. Achlorhydria, Hemoglobin 14.4 Gm.

Sept. 23, 1942; Routine examination (Fig. 2, *A*) negative.

Aug. 24, 1945; Second examination (Fig. 2, *B*) negative.

April 23, 1947; Third examination negative.

Nov. 12, 1947; Fourth examination (Fig. 2, *C*), minor changes on lesser curvature observed (arrow) but uncertain diagnosis led to no action.

Jan. 6, 1948; Fifth examination (Fig. 2, *D*) to recheck questionable findings. Considered negative but in retrospect definite infiltration on lesser curvature is present (arrow).

Aug. 10, 1948; Practically no symptoms. Achlorhydria. Hemoglobin, 12.5 Gm.

Aug. 10, 1948; Sixth examination (Fig. 2, *E*). Definite infiltrative carcinoma found (arrow).

Operation Sept. 16, 1948, subtotal resection. Flat adenocarcinoma of antrum. Lymph nodes negative. Patient still alive and well Jan. 8, 1954, well over five years after the operation.

A slowly growing infiltrative tumor is exhibited in this case. The patient should have been operated upon almost a year earlier if extremely small changes in the roentgenogram had been given sufficient credence. Despite some delay and definite growth the tumor was still curable. The advantages of repeated roentgen study with comparison, are illustrated.

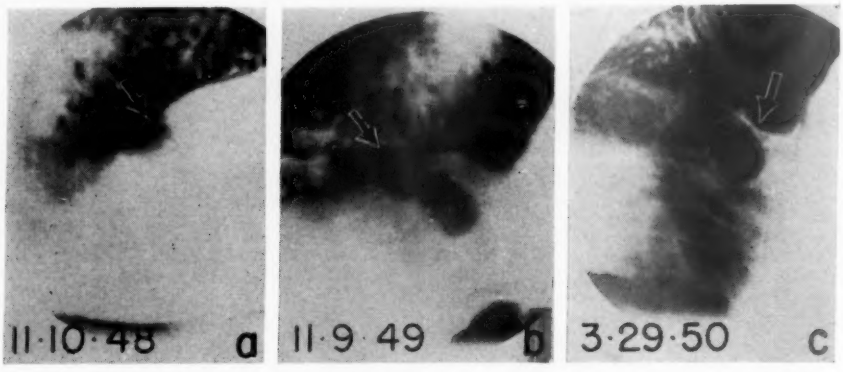

Fig. 3.—Case 2. Spot films of distal third stomach at various times to show development of polypoid carcinoma. *A*, Questionable defect on lesser curvature less than 1 cm. in diameter. *B*, Clear cut defect characteristic of polyp with pedicle. *C*, Eighteen months after first sign of abnormality, moderate increase in size of defect.

CASE 2.—Woman, 73 years, asymptomatic, cancer detection case. Achlorhydria, Hemoglobin 14 Gm., Stools negative.

April 2, 1948; Roentgen examination negative.

Nov. 10, 1948; Second examination (Fig. 3, *A*) reported negative. In retrospect there is a very small defect on lesser curvature (arrow).

Nov. 9, 1949; Third examination (Fig. 3, *B*). Defect found in antrum (arrow), considered to be benign polyp.

Feb. 23, 1950; Gastroscopy negative.

March 29, 1950; Fourth examination (Fig. 3, *C*). Polyp again seen and showed little change.

Nov. 8, 1950; Slight weight loss. No symptoms otherwise. Achlorhydria, Hemoglobin, 15 Gm. Stool negative.

Nov. 9, 1950; Fifth examination. Essentially no change.

Operation Jan. 31, 1951, subtotal resection. Malignant polypoid carcinoma found. Lymph nodes negative.

This type of tumor grows slowly. It was probably present in small size 27 months before operation; the change from November, 1948, to November, 1949, should have been a warning of the malignant character of the lesion. Such cases illustrate the fact that some carcinomas of the stomach can be salvaged even though examinations are done at yearly intervals.

CASE 3.—Man, 50 years, asymptomatic, cancer detection case, achlorhydria, Hemoglobin 15.3 Gm. Stools negative.

March 1, 1951; Roentgen examination (Fig. 4, *A*). Large folds, not considered to be polypi. In retrospect, what was thought to be a large fold (arrow) may have been a tumor defect.

May 14, 1952; Asymptomatic. Achlorhydria. Hemoglobin, 15.7 Gm., stools negative.

May 15, 1952; Second examination (Fig. 4, *B*). Polypoid tumor in antrum (arrow) possibly malignant.

Operation June 1, 1952. Polyp 2 cm. in diameter removed locally; histologic examination indicated a malignant polypoid tumor. Subtotal gastric resection was then done. Lymph nodes negative.

Such polypoid tumors seem to be relatively indolent but unless removed early they may become much more malignant.

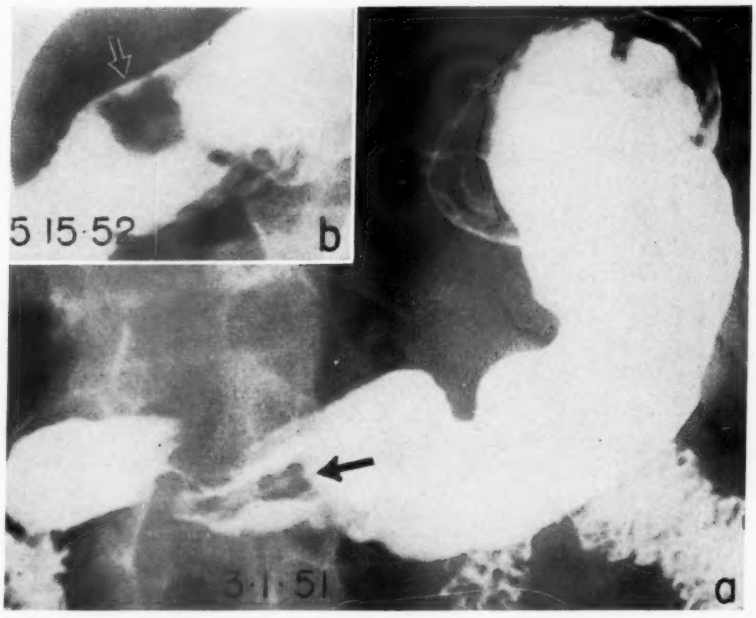

Fig. 4.—Case 3. Polypoid carcinoma simulating enlarged mucous membrane. *A*, Original examination. *B*, Moderate growth in fifteen months as shown by spot films, but still surgically controllable.

CASE 4.—Man, aged 60, with symptoms of heartburn; free HCl. 16 units, Hemoglobin 85 per cent, stool negative.

Nov. 24, 1941; Roentgen examination (Fig. 5, *A*), bayonet type stomach, negative.

March 21, 1943; Anorexia, minor weight loss. Achlorhydria. Hemoglobin 81 per cent. Stool positive for blood.

March 22, 1943; Second examination (Fig. 5, *B*). Infiltrating carcinoma, annular, involving antrum.

Operation April 21, 1943, subtotal resection, ulcerating adenocarcinoma distal third found. Lymph nodes negative. Patient expired from other causes Aug. 21, 1950, aged 69, well beyond five-year period.

The original films seem negative even in retrospect. Although 16 months intervened between examinations, the situation was still favorable and the patient was cured.

CASE 5.—Man, aged 74, pernicious anemia, no symptoms. Achlorhydria. Hemoglobin 9.9 Gm., stool doubtful positive for blood.

April 28, 1949; Roentgen examination (Fig. 6, *A*) reported negative. In retrospect there appears to be a minor rigidity and infiltration on lesser curvature (arrow).

Nov. 29, 1949; Minimal symptoms. Hemoglobin 14.5 Gm. Stool positive for blood.

Fig. 5.—Case 4. Roentgenograms made at interval of sixteen months. *A*, Original. Appears to be normal "Bayonet" type stomach. *B*, Characteristic infiltrating carcinoma in distal third. Despite the extent of the lesion and the sixteen-month interval a surgical extirpation resulted in a five-year survival.

Nov. 30, 1949; Second examination (Fig. 6, *B*), typical infiltrating carcinoma lesser curvature, extensive.

Operation Jan. 13, 1950, total gastrectomy. Diffuse scirrhous carcinoma, fundus of stomach extending to esophagus. Regional lymph nodes positive. Expired Nov. 5, 1950.

Here again minimal changes are seen in retrospect. The rapid growth of this type of carcinoma is well illustrated. It is notable that the only real sign of the lesion, aside from the x-ray findings, even at the end, was the evidence of microscopic blood in the stool.

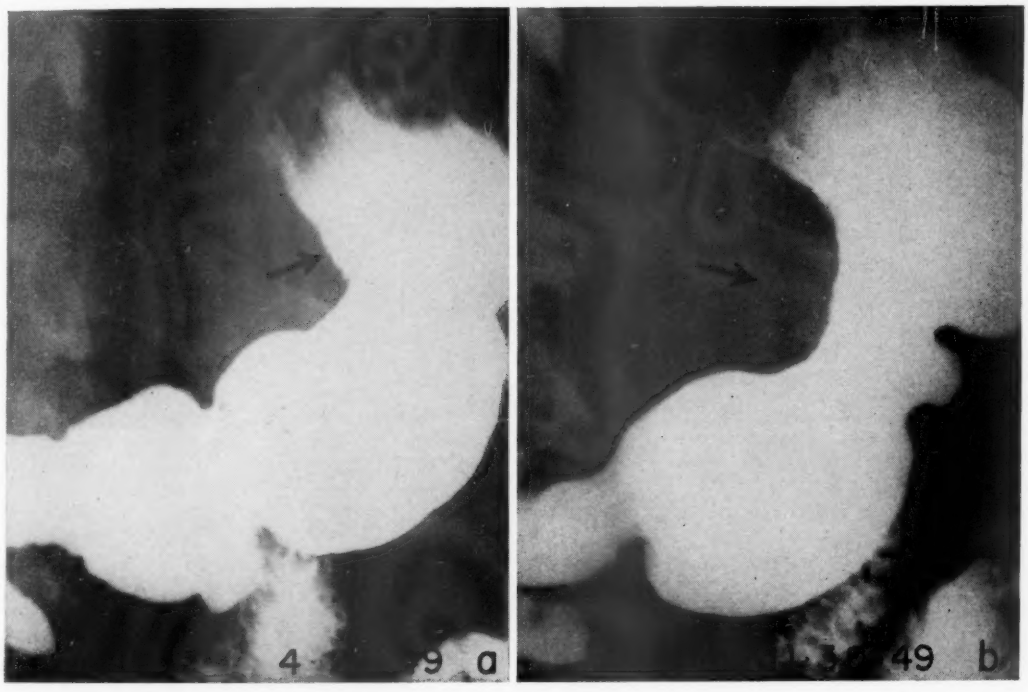

Fig. 6.—Case 5. Pernicious anemia patient, symptomless, routine roentgen examination. *A*, First examination considered to be negative but, in retrospect, infiltration is present on lesser curvature (arrow). *B*, Seven months later the lesion is very extensive and lymph nodes were extensively involved.

Case 6.—Man, aged 54 years, minor symptoms. Achlorhydria. May 7, 1937; Roentgen examination (Fig. 7, *A*). Pyloric stenosis.

Feb. 26, 1948; Achlorhydria after histamine. Minor symptoms.

Feb. 27, 1948; Second examination (Fig. 7, *B*), no change.

Sept. 21, 1949; Third examination (Fig. 7, *C*). Considered to be no change, but in retrospect possibly minimal infiltration on lesser curvature (arrow).

April 5, 1950; Achlorhydria. Hemoglobin 12.7 Gm. Moderate gastric symptoms.

April 6, 1950; Fourth examination (Fig. 7, *D*). Extensive ulcerating carcinoma of the stomach.

Operation May 12, 1950, subtotal resection. Large ulcerating carcinoma infiltrating pancreas. Lymph nodes showed no signs of carcinoma but patient expired one year later apparently from extension of tumor.

The presence of the pyloric deformity led to some of the re-examinations but had no relationship to the tumor. The lesion may be manifest in the roentgenogram seven months before the diagnosis was made, but it may be that this is only in retrospect. The case is an example of the difficulties encountered in routine examinations. It is also an example of extremely rapid growth as illustrated by the great difference between Figs. 7, *C* and 7, *D*.

CASE 7.—Woman, 51 years, minor complaints of epigastric pain, achlorhydria, Hemoglobin 12 Gm., stool negative for blood.

Feb. 11, 1946; Roentgen examination (Fig. 8, *A*) considered negative. In retrospect possible rigidity of curvatures, a diffuse change of questionable significance.

Jan. 13, 1947; Symptoms and laboratory findings unchanged but questionable epigastric mass now present.

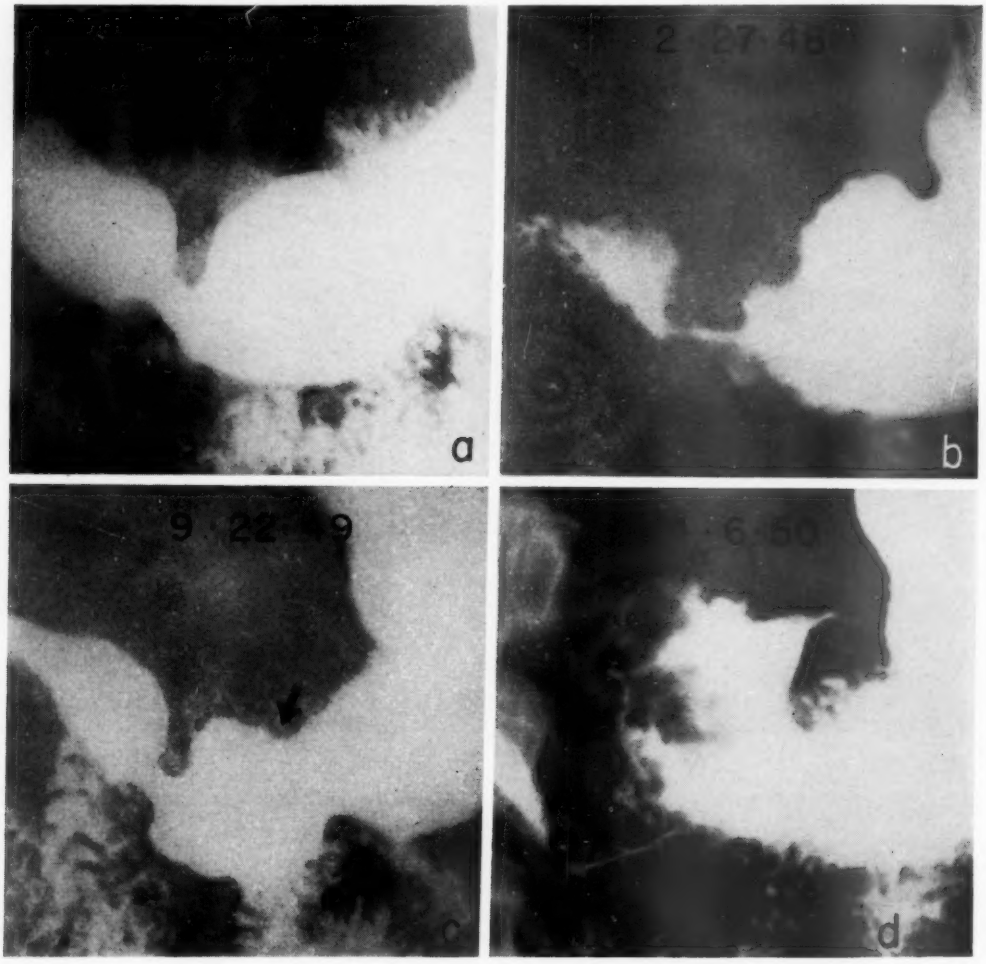

Fig. 7.—Case 6. Prolonged study in patient with symptoms. *A*, Pyloric stenosis first seen 1937. *B*, Seen again in 1948. *C*, In 1949, in retrospect, minimal change on lesser curvature (arrow). *D*, Six months later extensive ulcerating carcinoma already present.

Jan. 14, 1947; Second examination (Fig. 8, *B*). Typical diffuse infiltrating carcinoma, chiefly in antrum, but involving practically entire stomach.

Operation Feb. 25, 1947. Extensive infiltrating carcinoma involving entire stomach and distal end of esophagus. Considered nonresectable. Lymph nodes positive.

This is the type of case which may not be benefited by routine examination. The advance is rapid and involvement of lymph nodes is commonly present even when the lesion is small.

The group described above is a selected one, that is, cases of carcinoma of the stomach which had a gastrointestinal examination six to forty-eight months prior to the

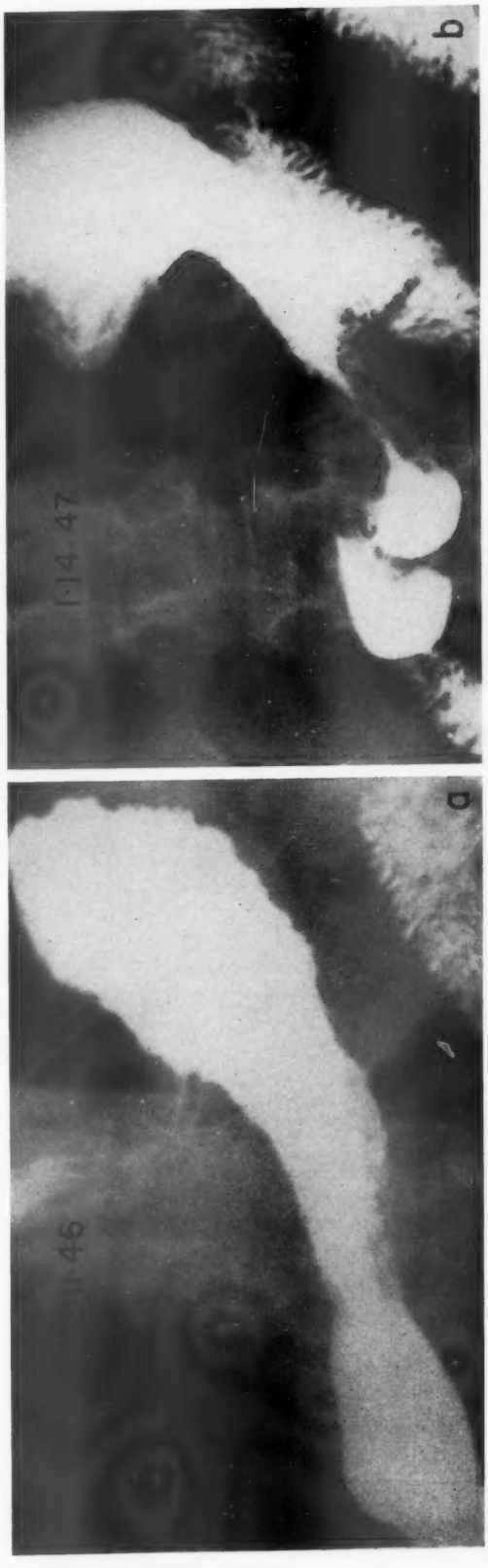

Fig. 8.—Case 7. Rapid change in a case of diffuse infiltrating carcinoma. *A*, First examination thought to be negative but submucosal infiltration may have already been present. *B*, Eleven months later the infiltration involves the entire stomach and it proved to be nonresectable.

establishment of the diagnosis of gastric cancer. The results of surgery in such a group are of great interest but must necessarily be compared to a control group of unselected cases.

CONTROL MATERIAL

For purposes of comparison, all the cases of proven gastric carcinoma studied by x-ray examination during the twelve-year period (1939 through 1950) were reviewed. There were 866 cases in this group which included many of the 78 cases previously discussed. The control group is not identical with the series of patients operated upon for gastric carcinoma during this same period in the University of Minnesota Hospitals since an appreciable number of the cases treated surgically here were diagnosed on the basis of x-ray examinations made elsewhere. Not all the cases in the control group were operated upon, but almost all of them were so clear cut that the diagnosis seems unequivocal. They represent reasonably well a group of patients with symptoms and signs suggestive of gastric cancer diagnosed by roentgen examination and proved eventually by operation, autopsy or end results.

Various points of comparison have been made between the control group and the selected cases previously described. The data are shown in Table I.

TABLE I.

	SELECTED GROUP	CONTROL GROUP
Number of cases	39	866
Sex ratio M:F	2:1	3:1
Median age	71 yrs.	66 yrs.
Achlorhydria		
No.	27/38	497/720
Per cent	71	69
Operability		
No.	35	669
Per cent	90	77
Refused surgery—No.	2	61
Resectability		
No.	28	410
Per cent	72	47
Negative lymph nodes		
No.	18	129
Per cent of whole group	46	15
Per cent of those explored	55	21
Per cent of those resected	64	31

DISCUSSION

It can be observed that there is a marked similarity in the data as regards age, sex, and even gastric acidity. This would appear to indicate that there has been no unsuspected selection of a favorable group of cases. It is only fair to note, however, that the number of polypoid lesions in the selected group, about 15 per cent, is several times larger than in the usual series of gastric cancers. Since polypoid lesions have a generally more favorable prognosis than other types, this difference may have been a slight factor in the smaller number with lymph node involvement.

The incidence of operability was distinctly greater in the selected group. It should be noted that in our clinic the indications for operability are very

broad since some of the operations in the advanced cases are on a palliative basis. The considerable difference in the percentage of those resectable indicates that the special group had much less extensive disease and there were fewer with distant metastases.

The data which appear to be the most important are those related to the involvement of lymph nodes. This characteristic is by far the most clean cut criterion for separating cases of carcinoma of the stomach as to their degree of development. In general, lymph node involvement indicates a later stage of the disease and accurately reflects the prognosis. Balfour,[1] Wangensteen,[27] and many others have consistently presented data which indicates that approximately half of those patients without evidence of lymph node spread will survive five years.

It is evident at once that the report of the pathologist as to negative lymph nodes cannot be taken as absolute. It has been shown by Coller[4] that in the routine pathologic examination about two-thirds of those with actual lymph node involvement are detected. It is also likely that the completeness of the pathologic examination varies from institution to institution.

While the number of cases is admittedly small, there seems to be a significant difference in the two groups. Regardless of how the percentages are calculated the frequency of negative lymph nodes is substantially greater (as much as three to one) in the selected group as compared with the controls. Considering the prognostic data of Balfour,[1] which is borne out by our own experience in this hospital,[27] a threefold increase in the number of cases with negative lymph nodes, if generally found, would produce a striking increase in five-year survival rates from carcinoma of the stomach.

The five-year survival rates in these cases will not be available for a number of years and we hope to publish this data eventually. At this time, however, we believe that the material indicating the presence or absence of lymph node involvement is so significant that it demands attention.

The average (twenty-two months) and the median (fourteen months) intervals between examinations are of great interest. They reveal that while an interval of three months between roentgen examinations may be desirable, it is possible to lengthen this period very considerably and still improve the percentage of early cases detected and, of course, also improve the prognosis. The data also suggests that the average growth and spread of gastric cancer is somewhat slower than has been previously considered. This is borne out by the individual study of the cases as reported above.

There was a greater number of diagnostic errors in the selected group. Such a finding emphasizes the difficulty in recognizing small malignancies. While Templeton[25] has expressed the belief that increased diagnostic accuracy is not the answer to the early detection of cancer of the stomach, it is likely that in the examination of symptomless individuals increased diagnostic accuracy would be of great importance.

In reviewing the errors in interpretation it is important to observe how closely a small malignant lesion may simulate a benign ulcer, a benign polyp,

or even an anatomic variation. In the course of this study no new method of identifying small gastric cancers was observed. It is apparent from our experience that the most careful fluoroscopy, spot films of all suspicious lesions, and many routine films were necessary to recognize such small lesions. The roentgenograms seem to be of special importance in the recognition of infiltrative areas while fluoroscopy was the most important in finding the polypoid or bulky type of lesion.

The findings reported above would seem to indicate that there is a real virtue in the roentgen examination of symptomless individuals for carcinoma of the stomach and that despite some biologic predeterminism, a much better prognosis is evident in such cases. The problem of applying such routine examinations on a wide scale, however, has not at all been solved and certainly, at the moment, such wide scale routine examinations of the stomach are completely impractical.

SUMMARY

Clinical, roentgen, and pathologic findings are reviewed in 39 cases of gastric cancer, selected because the positive roentgen diagnosis was made after an earlier negative one, thus indicating relatively early or small lesions. The findings indicate that a substantial increase in the number of surgically resectable and curable cases of gastric carcinoma may be obtained by serial roentgen examinations of relatively symptomless individuals. The findings also indicate that re-examination at reasonable intervals, as long as twelve months, would have a pronounced favorable effect upon the salvage from carcinoma of the stomach.

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MEASUREMENT OF GASTRIC SECRETION BY CATION EXCHANGE COMPOUNDS

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THE use of cation exchange indicator compounds to determine gastric acidity was introduced by Segal, Miller and Morton[4] in 1950. These authors used a quininium cation exchange resin from which the hydrogen cations released quinine as the indicator substance. The quinine is absorbed from the intestinal tract and excreted in the urine. The test has proved to be a valuable and reliable measurement of the presence or absence of hydrochloric acid secretion by the stomach. However, the amount of quinine excreted in the urine during the test period has not been found to correlate in vivo with the amount of hydrochloric acid secreted. Segal and associates have attributed this to variations in the gastric emptying time. Malach and Banks[2] and Pollard, Carballo, and Bolt[3] also found that the test was only very roughly quantitative and could not be considered to measure pH or units of acid. Shay, Ostrove and Siplet[5] studying patients following gastrectomy for peptic ulcer confirmed this lack of quantitative correlation between directly and indirectly measured hydrochloric acid production. In a more recent report, on the other hand, Donovan and Tighe[1] observed that the amount of quinine excreted in the urine during the first three hours after the patient swallowed the exchange resin reflected accurately the amount of N/10 hydrochloric acid that could be aspirated from that patient's stomach. Over 100 patients were studied by this method.

We have been attempting to correlate the pattern of basal gastric secretion in patients with peptic ulcer with the clinical results obtained by the application of various methods of surgical treatment. Direct measurements of gastric secretion in the postoperative stomach are notoriously difficult because of rapid gastric emptying and reflux of alkaline duodenal content. The value of an indirect method of measuring hydrogen ion production by the parietal cells of the stomach is apparent. We have attempted to obviate variations in gastric emptying time by giving the exchange resin in divided doses at short intervals rather than in a single dose, in the hope that an excess of the material could be maintained in the stomach.

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METHOD

A group of 73 patients with peptic ulcer were studied. Basal gastric secretion was measured in the following manner. The patient was given a light meal at five P.M. and allowed nothing by mouth thereafter. At eight o'clock the following morning a No. 16 Fr. Levine tube was passed into the stomach and carefully placed under fluoroscopic control along the lesser curvature into the proximal portion of the antrum. Continuous aspiration was provided at 70 mm. Hg negative pressure. Intermittent suction with glass syringes was carried out every fifteen minutes in order to insure patency of the tube. The continuous secretion of gastric juice was collected for 4 one-hour periods. The volume of each hourly sample was measured and the sample titrated for free acidity. The secretion of free HCl was then reported in meq. per hour by averaging the free HCl content of the four samples.

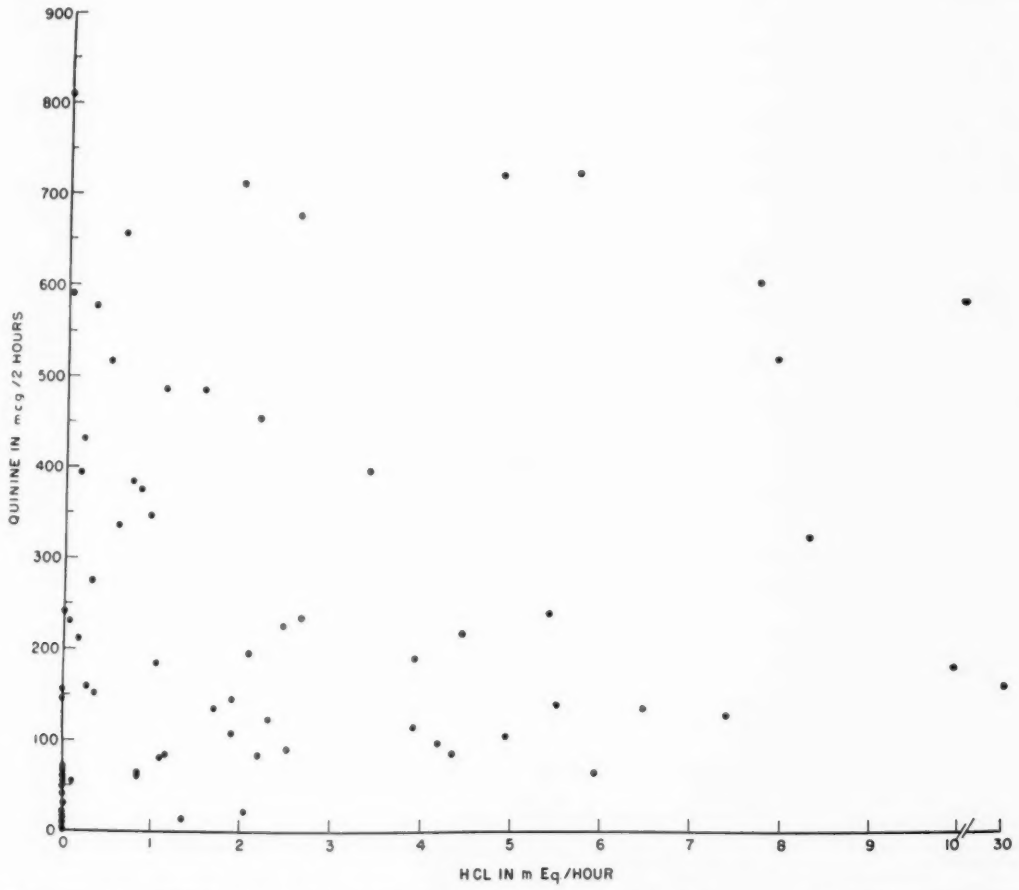

Fig. 1.—Relationship between free hydrochloride acid output of the stomach and urinary excretion of quinine from quininium exchange resin in 73 patients.

On another day while in the basal digestive state as described above the patient was given 2 Gm. of quininium exchange resin (Diagnex)* orally in 150 c.c. of water. The same dose was repeated three more times at fifteen-minute intervals making a total of 8 Gm. of Diagnex and 600 c.c. of water. Two hours after the ingestion of the first dose, urine was collected. The quinine content of the two-hour urine sample was measured and compared with a fasting urine sample obtained prior to the test using the ether extrac-

*Provided through the courtesy of Marshall I. Hewitt, M.D., Squibb Institute for Medical Research, New Brunswick, New Jersey.

tion method described by Segal and associates.[4] Excretion of quinine was recorded as micrograms of quinine excreted in two hours. In each patient the study was repeated three times and the final result reported as the average of the three tests.

RESULTS

The results obtained in 73 preoperative peptic ulcer patients are presented as a scattergraph in Fig. 1. Except for a cluster of points near the 0 for both abscissa and ordinate, there is a seeming complete lack of correlation between directly measured hydrochloric acid output and quinine excreted in the urine. The correlation coefficient is calculated to be 0.02, indicative of extremely poor correlation.

Seven patients were studied who had a gastrojejunal or marginal ulcer following a previous partial gastrectomy performed for a duodenal ulcer (Table I). Following studies of the basal gastric secretion and the quinine excretion after ingestion of quininium exchange resin, transthoracic vagotomy was carried out in each of the seven cases. Unfortunately gastric secretion has been measured in only two of the seven patients postoperatively. In all seven cases, however, there was a reduction in the two-hour output of urinary quinine following the multiple dose Diagnex test and in five this reduction was profound. A prolonged follow-up study of these patients is planned.

TABLE I. THE URINARY EXCRETION OF QUININE FOLLOWING INGESTION OF QUININIUM CATION EXCHANGE RESIN IN PATIENTS WITH MARGINAL ULCER

PATIENT	BEFORE VAGOTOMY		AFTER VAGOTOMY	
	HCl OUTPUT (MEQ./HR.)	QUININE (MCG./2 HR.)	HCl	QUININE
S. A.	1.10	483	0	11
C. O.	0.61	336	0	16
C. R.	0.33	152		0
F. L.	0.11	56		19
H. I.	6.48	151		73
A. I.	0.18	401		10
R. O.	1.91	117		2

DISCUSSION

Despite the use of a multiple dose technique in an effort to overcome differences in gastric emptying time it has not been possible to correlate in quantitative fashion the basal secretion of acid gastric juice as measured directly with the secretion of acid measured indirectly using the quininium ion exchange resin. The reasons for this failure are not apparent, since, in vitro, close correlation can readily be obtained. The results presented in this study are in accord with those previously presented by others[2-5] whether studying basal or stimulated gastric secretion. We have been unable to confirm the results reported by Donovan and Tighe.[1]

Despite the over-all lack of quantitative correlation the findings in seven patients with marginal ulcer are most interesting. In all cases a reduction in the quinine excreted in the urine was obtained after transthoracic vagotomy. If gastric emptying time is responsible for the lack of correlation in this study

the latter finding is the reversal of what could be anticipated since vagotomy should slow gastric emptying and allow more complete interaction between hydrogen ions present and the cation exchange resin. The potentialities of such indicator substances in the postoperative stomach are apparent. It is intended to extend this study over an increased number of cases in an effort to correlate the objective secretory studies with the clinical results obtained by such surgical procedures.

In comparing the results of the present study with those previously reported it is at once apparent that the multiple dose method of Diagnex administration holds no advantages over the single dose method. Except in the low range of secretion approaching anacidity there is no quantitative correlation between the direct and indirect methods of measuring HCl output by the stomach.

SUMMARY AND CONCLUSIONS

1. Basal gastric secretion has been determined by direct aspiration of the stomach and compared with the amount of quinine excreted in the urine following the ingestion of multiple doses of Diagnex, a quininium cation exchange resin.

2. No correlation has been found between the basal gastric secretion measured directly and indirectly in this fashion, except in the ranges at and approaching anacidity. These results are in accord with most previous investigators.

3. In seven patients with marginal ulcer following partial gastrectomy, transthoracic vagotomy caused a moderate to marked reduction in the urinary excretion of quinine following ingestion of the quininium exchange resin. Possible uses of this finding are discussed.

4. It is concluded that basal gastric secretion cannot be quantitatively measured by ion exchange resins currently available, and that the multiple dose method has no advantages over the usual single dose technique.

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DESCRIPTION AND USES OF A NEW GASTRIC AND INTESTINAL TUBE

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BROADENING of the scope of gastrointestinal surgery is being made possible today not so much by refinements in surgical handicraft but by refinements in the care of patients before, during, and after surgery.

Correction of a single factor in this multifaceted complex may well mean the favorable weighting of balance in an otherwise desperate situation where errors are compounded and gains are barely additive.

One of the most commonly upset balances in surgical patients is that between secretion and absorption, and retention and expulsion of gastrointestinal contents. This has long been recognized and innumerable physicians have devised tubes which, inserted into the stomach or intestine, have been used to correct and to study this balance.

HISTORICAL REVIEW

Prior to 1908, various techniques were utilized in the diagnosis and treatment of various gastrointestinal disorders. Sounds and various types of tubes were used. However, by virtue of their inflexibility, accidents such as hemorrhage and fixation within the intestinal tract required surgical exploration for removal. Dr. G. Scheltema,[12] in 1908, coined the term "permeation," meaning that the instrument or sound was carried through the gastrointestinal tract by peristaltic action. His tube was flexible and its terminal end was slightly bulbous. The advantage of this was to allow the peristaltic activity of the intestine to better grasp this bulbous end and aid in its passage along the intestinal tract. This tube was used for diagnosis and treatment of intestinal diseases. It is of interest that Scheltema used this technique of "permeation" for the feeding of infants, and also described a rubber tube filled with mercury which could be passed into the intestine via the nose in frogs.

Dr. Scheltema's tube was made of rubber, and was passed through the entire intestinal tract and removed by rectum. It was used chiefly in feeding and in instillation of medications for the treatment of "cholera infantum" and for the treatment of intestinal parasites. No record of a tube used for intestinal suction is noted until Dr. Westerman,[14] in 1909, used the duodenal tube for the relief of distention secondary to peritonitis.

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In 1919, Dr. Max Einhorn[8] devised his first tube. This was a soft rubber tube, 15 to 20 feet in length, and 8 mm. in circumference. At the distal end was fixed a metal capsule with numerous perforations. The proximal end terminated in a stopcock and within the tube fastened at both ends was a strong braided silk thread. Markings were painted on the tube to show the level of intubation. The first modification of the Einhorn tube was made in 1920. This consisted of the usual duodenal tube but having metallic threaded tips, one end being fitted with a male thread and the other, a female thread. There were many one-meter lengths of such a tube so that one section could be screwed upon the other thus varying the total length of the tube as desired and thereby forming a jointed tube.

Great care and patience were necessary to pass numerous lengths of this "jointed tube." The clinical test was to allow a certain length to enter the stomach and, if resistance was felt while gently tugging on the proximal end, the tube had probably passed through the pylorus into the small bowel. As passage of the tube progressed, various lengths were added. Dr. Einhorn used this tube for colon lavage in the treatment of ulcerative colitis.

Fear of bowel perforation by the weighted metallic tip lying in contact with the bowel for several days was eliminated by Dr. Buckstein,[4] in 1920, by his fixation of the metallic tip to the rubber tube, using chromic catgut. The dissolution of the chromic catgut would allow passage of the tip with the tube remaining in place. Dr. Buckstein used the single lumen tube for the instillation of barium mixture in order to study the small intestine by roentgenogram.

In 1921 Dr. A. L. Levine[10] described his now famous tube, recommending its use for gastric and duodenal drainage and analysis. Dr. Owen H. Wangensteen[13] in 1933 was the first to use a tube for decompression in certain intestinal obstructions.

The double lumen tube was first devised by Dr. T. G. Miller and Dr. W. O. Abbott,[11] in 1934. One lumen was for inflation and deflation of a rubber bag, and the other lumen for the purpose of suction and instillation of various substances.

In 1936[2] they modified this tube by making a three-lumen tube with two collapsible balloons. One balloon was at the distal end, and the other at a variable distance proximally. This tube was devised for the purpose of aspirating intestinal contents at different levels, and for the study of intestinal absorption. Further modification of their tube was made in 1938[1] with one very large lumen to facilitate aspiration of intestinal contents, and the other lumen smaller to allow for introduction of air or mercury into the balloon.

In 1939 Abbott and Rawson[3] described a double lumen tube which was used for drainage of stomach contents, and the simultaneous feeding into the small intestine after subtotal gastrectomy.

A method to facilitate the passage of the mercury-air tube was suggested by Dr. Harris[9] in 1944. A small amount of mercury was instilled into the balloon, and when it had passed through the pylorus it was inflated with air.

The single lumen tube of Dr. Meyer O. Cantor[5] was devised in 1946. This tube was 10 feet in length with a rubber balloon at the distal end. The luminal diameter was $\frac{3}{16}$ inch, with a wall thickness of $\frac{3}{64}$ inch, and perforated with a series of holes in the distal 24 inches of the tube.

An innovation in intestinal tubes was made by Dr. John W. Devine, Jr.,[6] who devised a tube to eliminate the vacuum mucosa obstruction phenomenon. He placed a small diameter, multiperforated polyethylene tube within a larger single lumen tube. The outer tube was applied to suction, and the inner tube provided an air vent so that atmospheric air sucked down this small plastic tube thereby eliminating the "vacuum mucosa obstruction phenomenon."

Devine and Devine[7] described, in 1953, the use of magnetic tipped tubes to aid in passage of the tube through the pylorus by use of a large magnet and fluoroscopy.

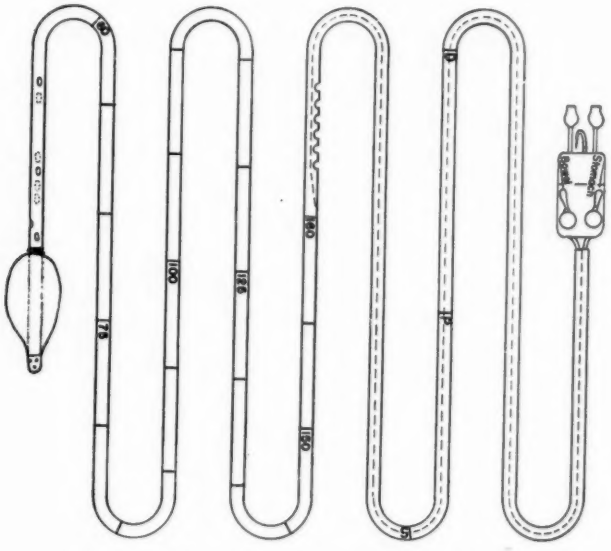

Fig. 1.—Diagram of gastrointestinal tube.

For the past year we have on occasion been using a single all-purpose tube which is useful for instituting drainage and decompression, for instilling fluids, or for aspirating secretions from various portions of the gastrointestinal tract. It seems to possess most of the single advantages of various gastrointestinal tubes currently in use.

THE GASTRIC AND INTESTINAL TUBE

The tube* is an 18 Fr. rubber catheter 300 cm. in length, with a double lumen proximally and a single lumen distally. A perforated metal tip as well as multiple, adequate-sized perforations along the distal 20 cm. communicate through a single lumen with an outlet separate and distinct from the outlet draining the proximal double lumen which has its perforations

*This tube was manufactured for us by the United Surgical Company, 600 Halstead Ave., Mamaroneck, N. Y.

210 cm. from the proximal end of the tube. Passage of the tube is facilitated by a special pear-shaped, mercury-weighted rubber bolus located near the tip of the tube (Fig. 1).

The uses of this tube are as follows: (1) decompression of stomach simultaneously with the lower intestine (Fig. 2), (2) simultaneous estimation of

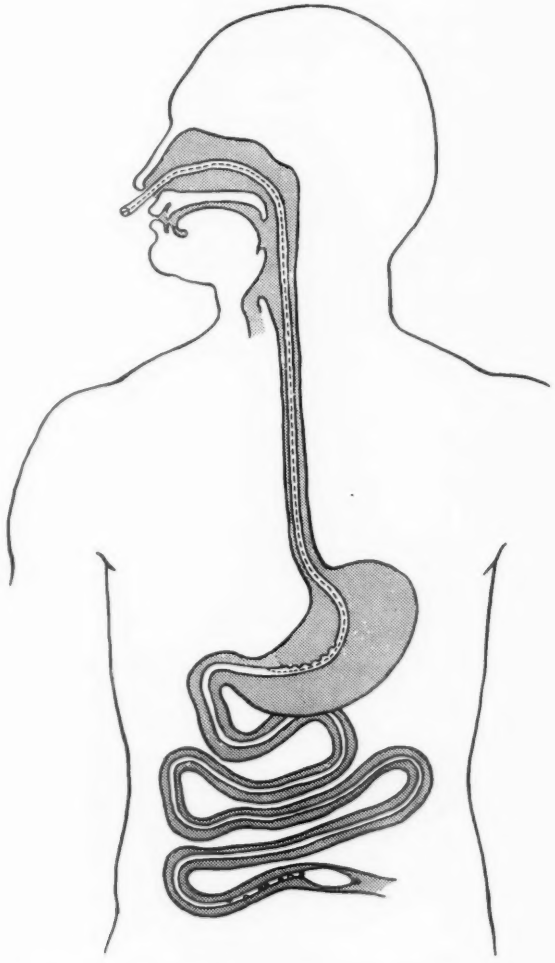

Fig. 2.—Diagram of gastrointestinal tube showing simultaneous decompression of stomach and small intestine.

the amount and type of secretions from the stomach and intestine for the purpose of study or replacement therapy, and (3) simultaneous decompression of the proximal gastrointestinal tract while nutrients are instilled into the intestine. The tube has the further advantage of being radiopaque and the double- and single-lumen portions can be separately identified by roentgenograms (Fig. 3).

On the surface of the tube there are identifying marks indicating the distance from the tip as well as the proximal end. Each lumen communicates

with a separate outlet designated "stomach" and "intestine" respectively and each is fitted with a permanent stopcock which can be opened or closed.

Directions for the passage of the tube (essentially the same as for the passage of any intestinal tube) are:

(1) To facilitate more rapid and certain intubation and to insure patient's comfort, give appropriate doses of atropine and sedative by hypo one hour before attempting passage of the tube, and apply topical anesthetic to nasal membranes 10 minutes before passage of the tube. (2) Inject 3 to 5 c.c. of mercury into the bag with a syringe and No. 21 gauge needle. Aspirate all the air remaining in the bag. (3) Lubricate the distal 10 cm. of tube with

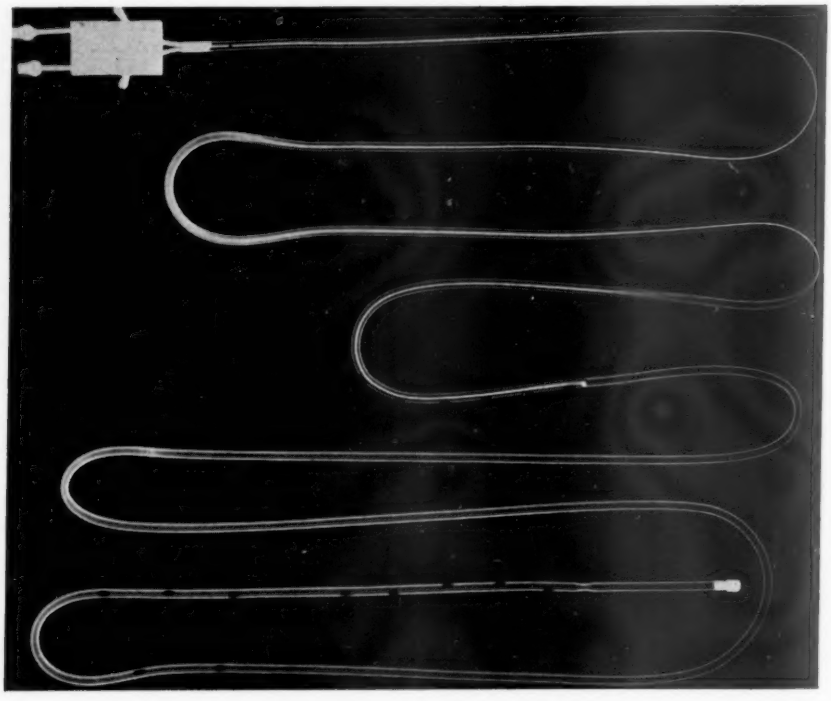

Fig. 3.—Roentgenogram of gastrointestinal tube for identification of gastric and intestinal openings.

appropriate water-soluble lubricant. (4) With patient on back and neck fully extended, place the mercury-weighted bag into the nostril and direct the tip of the tube toward the nasopharynx. (5) Then, with the patient in comfortable sitting position, the tube will be carried into the stomach with the help of the normal swallowing mechanism. (If patient gags excessively when tube is in posterior pharynx, withdraw tube several centimeters until gagging is controlled. Give patient a sip of water with instructions to hold it in the mouth until instructed to swallow. Then upon his swallowing the water, the tube can be gently passed down the esophagus.) (6) The average patient will require the tube to be passed about 50 cm. to reach the stomach. *At this time,* the stopcock designated "intestine" should be aspirated, for it is the so-called

intestinal portion of the tube which is now in the stomach. (7) If it is desired that the tube be permitted to pass the pylorus, it should not be taped or restrained in any way. Instead the patient should be placed on the right side for one to two hours or until the tube has passed the pylorus. In cases where there is known deformity of the stomach, different positioning may be required (as in elevation of the greater curvature by tumor or distention of transverse colon). It is often helpful in determining when the tube has passed the pylorus by noting a change in character of the drainage (e.g., clear gastric juice becoming bile stained, testing with pH paper, and so forth). The tube may be manipulated through the pylorus by fluoroscopic control. (8) One often finds that once the tube has passed the pylorus it will advance along the small intestine at a rate of 1 to 1.5 cm. per minute. In various pathologic conditions this rate is quite variable. The tube is marked off at 5 cm. intervals so that the rate of passage can be easily noted. (9) Once the tube is in the intestine and placement of a tube in the stomach is desired, one need merely advance the proximal portion of the tube until the mark "S" (designating "stomach") or "D" (designating "duodenum") is at the external nares. At this time the stopcock designated "stomach" may be aspirated. (10) As the final point it should be emphasized by reference to the guide marks at the proximal part of the tube when the distal portion of the tube is deep in the intestine.

CASE REPORTS

CASE 1.—O. R., a 53-year-old housewife, was admitted with intestinal obstruction due to recurrent rectal carcinoma. Flat plate of the abdomen was typical of mechanical upper small bowel obstruction. The gastric and intestinal tube was passed and suction produced 1,000 c.c. of drainage with some relief of distention. A palliative small bowel resection was done for metastatic implants and, postoperatively, the patient developed a paralytic ileus as well as gastric dilatation. The ileus was controlled by the indwelling intestinal tube and it was a simple matter to advance the gastric (proximal) portion of the tube into the stomach to drain and control the gastric dilatation. Accurate replacement therapy was also possible, and the patient did well. She was discharged on the tenth postoperative day.

CASE 2.—S. M., a 43-year-old man, was admitted with a history of duodenal ulcer and chief complaint of hematemesis. A Billroth I subtotal gastrectomy was done, and at that time the intestinal portion of the tube was passed through the anastomosis into the jejunum and the gastric portion was left proximal to the anastomosis. Postoperatively, this debilitated patient was able to accept jejunal feedings on the first postoperative day, while gastric dilatation was prevented and the suture line "protected" by suction on the proximal (gastric) portion of the tube.

CASE 3.—S. E., a 57-year-old woman, was admitted with cancer of the sigmoid. The night before surgery, the gastric and intestinal tube was inserted to insure its passage through the pylorus. An anterior resection was done and, postoperatively, the patient was kept on small intestinal suction with satisfactory decompression. On the evening of the second day, the patient developed severe respiratory distress and massive abdominal distention was noted. Again it was a simple matter to advance the proximal (gastric) portion of the tube and immediate evacuation of 500 c.c. of gastric contents and considerable gas was obtained. The patient was relieved and her subsequent course was uneventful.

SUMMARY

A brief historical review of the use of gastric and intestinal tubes is presented. A new gastric and intestinal tube is described and its uses and advantages noted.

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REVASCULARIZATION OF THE MYOCARDIUM BY AORTA TO CORONARY SINUS ANASTOMOSIS

Histologic and Physiologic Changes Noted at Six Months and Twelve Months After the Operation

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Beck and his associates[4, 10] have demonstrated in dogs that by placing a free vein graft between the aorta and coronary sinus, using a two-stage procedure known as the Beck No. 2 operation, it is possible to successfully retroperfuse the myocardium through the venous system. This reverse flow of arterial blood in the venous system is immediately capable of protecting the heart against acute coronary artery occlusion and does not depend upon the growth of new collaterals.[5, 7] Subsequent studies have shown that in the dog this retroperfusion is temporary and it disappears after five to seven weeks following the second stage of the operation.[6, 7] This is associated with a fibroelastosis of the walls of the coronary sinus and epicardial veins, which narrows or obliterates the lumen.[7, 8] By this time, however, there is a development of interarterial collateral channels which have been found to persist up to one year after the operation, and are capable of protecting the heart against acute coronary artery occlusion.[6, 7, 9] The chronic protection of the heart in dogs, by the Beck No. 2 operation lies in the development of intercoronary arterial communications.

We have performed the Beck No. 2 operation on dogs and investigated the status of retroperfusion and the collateral circulation at six months and twelve months after the second stage of the operation.

MATERIALS AND METHODS

The two-stage Beck operation was performed on thirteen mongrel dogs weighing 12 to 18 kilograms. In the first stage a free vein graft was placed between the aorta and coronary sinus. In the second stage, three weeks later, the coronary sinus ostium was narrowed to 2 to 3 mm. Mautz-Gregg studies were performed, six months following the second stage in six dogs, and twelve months following the second stage in the remaining seven dogs. This consisted of ligating the left circumflex coronary artery at its origin, transecting it distal to the ligature, and cannulating the distal segment. The blood which flowed from the distal segment was studied for volume flow per minute and oxygen content. These values were compared with those of blood simultaneously withdrawn from the coronary sinus, aorta, and

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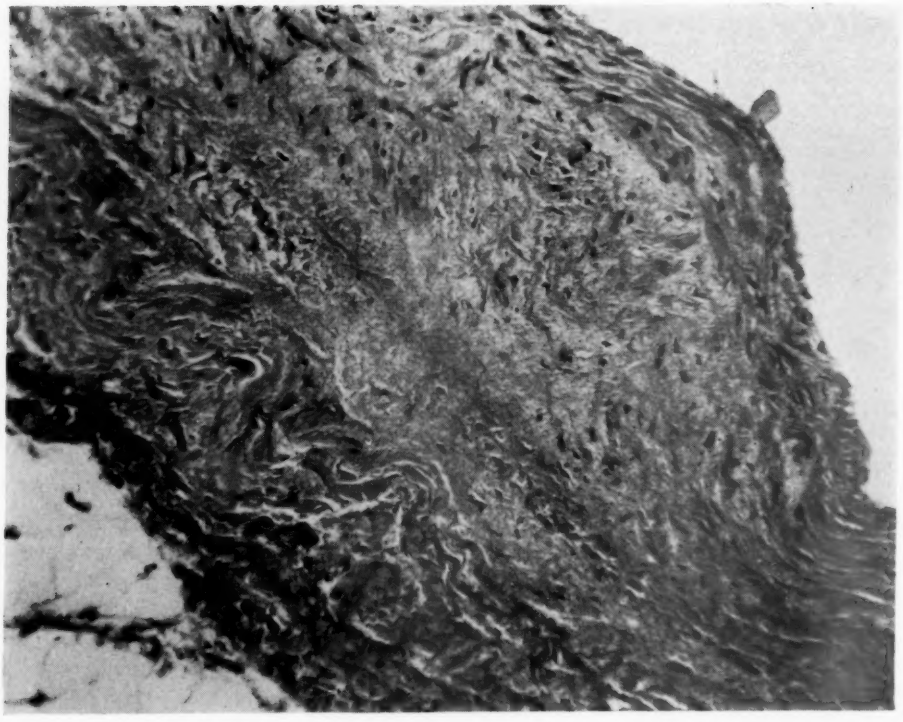

Fig. 1.—This view of the wall of the vein graft shows thickening due to fibroelastosis. The media and adventitia are not distinguishable. (Hematoxylin and eosin; ×120.)

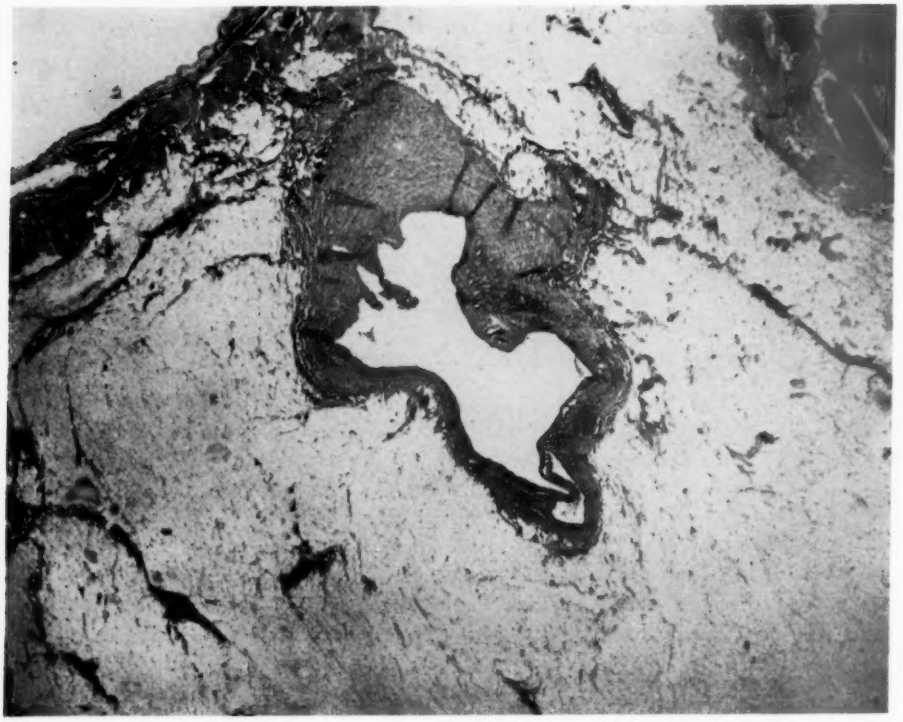

Fig. 2.—A view of the coronary sinus showing thickening of the wall by fibroelastosis. (Hematoxylin and eosin; ×15.)

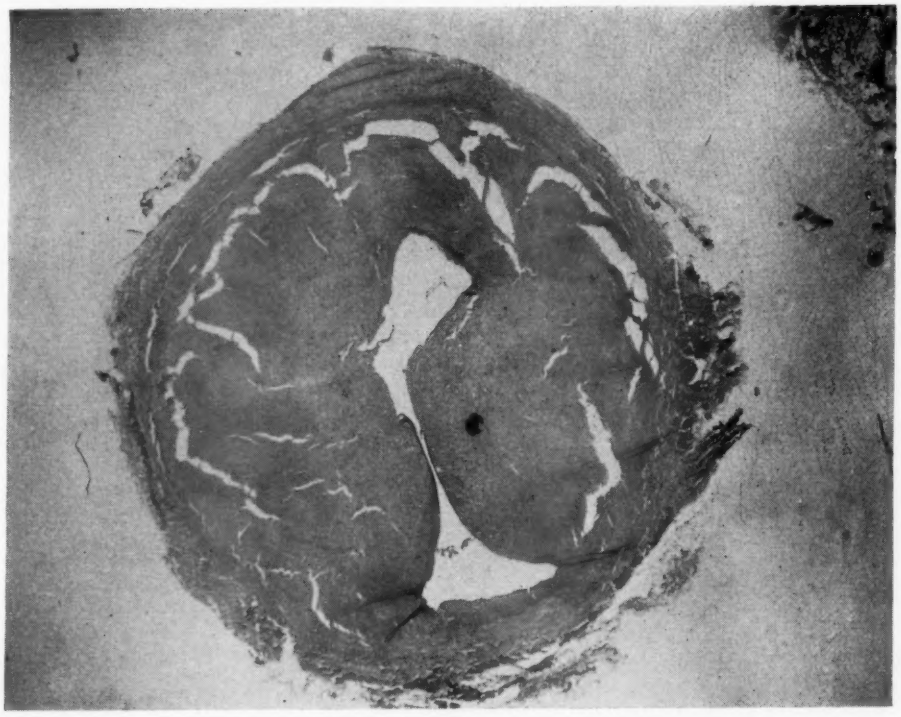

Fig. 3.—A view of the coronary sinus with an organized thrombus in its lumen. (Hematoxylin and eosin; ×15.)

Fig. 4.—A view of an epicardial vein and part of a coronary artery. The veins are narrowed by marked fibroelastosis and the artery wall is not altered. (Hematoxylin and eosin; ×26.)

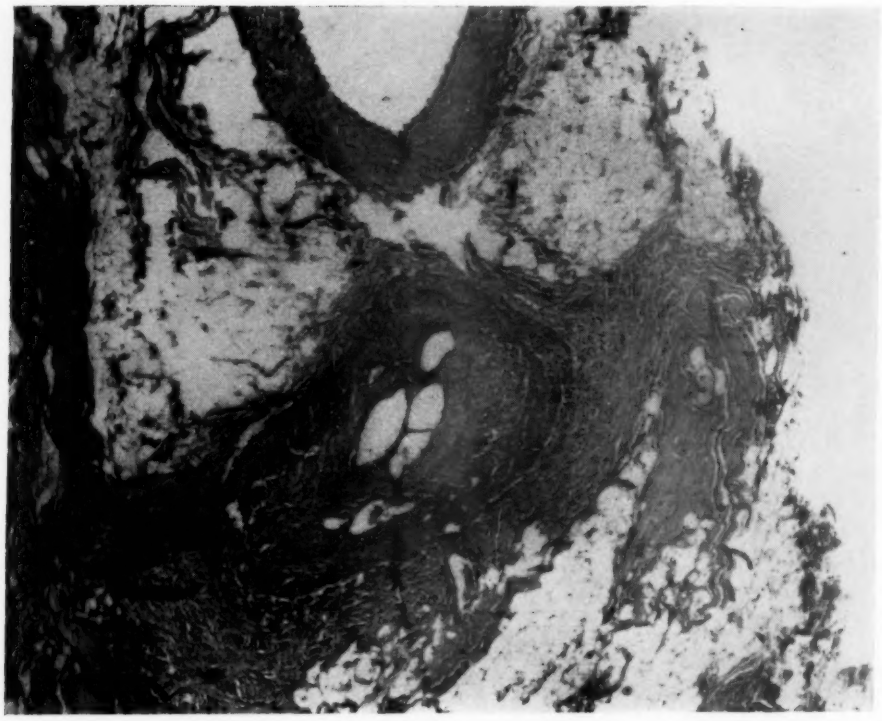

Fig. 5.—A view of an epicardial vein and part of a coronary artery. The vein shows an organized and recanalized thrombus. (Hematoxylin and eosin; ×26.)

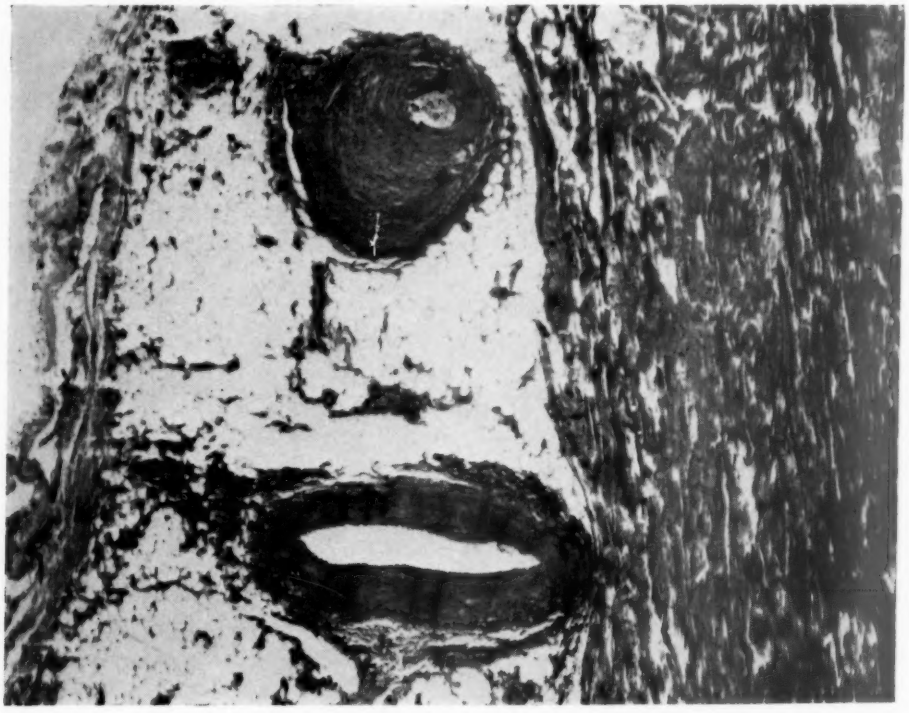

Fig. 6.—A view of an epicardial vein and coronary artery. The vein lumen is extremely narrowed by intimal fibroelastosis.

pulmonary artery. Following these studies the dogs were sacrificed and the hearts were fixed in 10 per cent Formalin. Sections taken from the vein graft, coronary sinus, and epicardial veins of the anterior, lateral, and posterior aspects of the left ventricle were stained with hematoxylin and eosin and Weigert elastic tissue stains.

PATHOLOGIC FINDINGS

Vein Graft.—In every case the vein graft was widely patent and the anastomotic site showed good union. The intima was lined by a single layer of endothelial cells beneath which there were proliferating collagen and elastic fibers which thickened the wall. The media and adventitia were difficult to distinguish because of the presence of increased quantities of collagen and elastic fibers.

Coronary Sinus.—The coronary sinus showed pronounced changes in its wall and narrowing of its lumen. Its wall was thickened by the presence of an increased quantity of connective tissue. The intima consisted of a single layer of endothelial cells beneath which lay an increased amount of collagen and elastic fibers, loosely arranged. The media and adventitia were disrupted by the proliferation of collagen and elastic fibers. The changes were most marked in the intima. The thickened walls narrowed the lumen; in some cases as much as 50 per cent of normal. In three dogs (one six-month dog and two twelve-month dogs) the lumen of the coronary sinus was occluded by an organized thrombus.

Epicardial Veins.—The severest changes were noted in the epicardial veins which drain into the coronary sinus. The walls of these veins were thickened by the proliferation of large quantities of collagen and elastic fibers, so that they had become thickened fibrous tubes. The media and adventitia were no longer identifiable. This thickening was eccentric in most cases and markedly narrowed the lumen so that a mere slit is all that remained. In some instances the lumen was replaced by a recanalizing collagenous mass interpreted as a recanalized thrombus.

Coronary Arteries.—The coronary arteries that accompanied the veins examined did not show any alterations in their walls.

Myocardium.—Focal areas of scarring, seen only microscopically, were found in some cases in both six-month and twelve-month dogs.

These findings apply to the hearts studied six months and twelve months after coronary sinus arterialization. No quantitative differences were noted in the two groups.

PHYSIOLOGIC FINDINGS

Table I represents a summary of all the physiologic data obtained in this laboratory on experiments in dogs with the Beck No. 2 operation. Except for the data obtained in the dogs followed for twelve months after the operation, all of it has been published to date.[1-3] The twelve-month data is to be published in detail in the near future.

A. In the animals in which the coronary sinus had been arterialized for six months, studies of the oxygen content of the retrograde blood flow from

the transected circumflex artery revealed that the dogs divide themselves into two groups. In Group B the oxygen content closely approximated that of aortic blood. In Group A the oxygen content approximated that of the pulmonary artery and represented mixed venous blood. In none of these animals did the oxygen content fall within the range of the normal coronary sinus as it did in the dogs studied two months after the arterialization.

After closing the vein graft the oxygen content, in both groups, rose further toward aortic levels.

Following occlusion of the vein graft the minute volume flow from the circumflex artery did not fall to control levels.

TABLE I. COMPARISON OF AVERAGE VALUES FOR MINUTE FLOW AND OXYGEN CONTENT OF BLOOD FROM DIFFERENT SOURCES

	CIRCUMFLEX ARTERY RETROGRADE BLOOD FLOW				AORTIC BLOOD	PULMONARY ARTERY BLOOD	CORONARY SINUS BLOOD	
	GRAFT OPEN		GRAFT CLOSED				GRAFT OPEN	GRAFT CLOSED
	FLOW C.C./ MIN.	O_2 VOL. PER CENT	FLOW C.C./ MIN.	O_2 VOL. PER CENT	O_2 VOL. PER CENT	O_2 VOL. PER CENT	O_2 VOL. PER CENT	O_2 VOL. PER CENT
Control dogs	1.7	14.5			15.3	10.6	4.5	
2 months after Beck No. 2 operation	12.2	6.3	7.1	15.5	17.0	12.1	14.0	3.6
6 months after Beck No. 2 operation								
A	10.3	12.6	9.9	16.1	17.6	12.9	17.3	6.8
B	6.1	16.2	7.5	17.1	17.1	13.7	17.4	9.5
12 months after Beck No. 2 operation	6.0	16.3	6.6	18.1	19.0	11.6	17.8	7.1

B. In the animals studied twelve months after arterialization of the coronary sinus, the backflow from the circumflex artery with the graft open had an oxygen content which approximated the aortic level. After closing the vein graft the minute volume did not fall.

DISCUSSION

The findings obtained on studying the backflow from transected left circumflex arteries demonstrate that retroperfusion does not persist in dogs with chronically arterialized coronary sinuses. At six months we found that the retroperfusion had ceased entirely or almost so. This was demonstrated by the fact that the oxygen content of the backflow from the circumflex artery had reached arterial levels, indicating that it was derived from a collateral blood flow. This corroborates the findings of Eckstein and associates[6, 7] who first noted that after the seventh week following the second stage of the operation, retroperfusion starts to disappear. By the twelfth month our dogs had findings indicating complete cessation of retroperfusion. The oxygen

content of the backflow had risen to approximately aortic levels and the minute flow had diminished considerably and was unaffected by closing the vein graft.

The physiologic findings are understandable when one investigates the histologic structure of the coronary sinus and epicardial veins. The histologic studies revealed an obliteration of the venous system which was produced by a proliferation of collagen and elastic fibers in the wall of the veins, principally in the intima. In some instances thrombosis occurred superimposed upon the thickened portions of the wall. These became organized and recanalized. These changes were most pronounced in the epicardial veins. No quantitative differences were noted in the histologic changes of the six-month and twelve-month dogs.

Of great importance was the demonstration of a persistently increased collateral blood flow twelve months after the operation. This was indicated by the persistence of an elevated minute volume flow of arterial blood after closing the vein graft. This has been reported by Eckstein and Leighninger.[6, 7, 9]

SUMMARY

The coronary sinus of dogs was arterialized using the Beck No. 2 operation. Physiologic findings performed at six months and twelve months after the operation revealed cessation of retroperfusion. This was associated with the histologic finding of an intimal fibroelastosis in the venous system which obliterated the lumen and in some cases was associated with thrombosis. At six months there was a significantly increased intercoronary collateral blood flow which was found to persist at the end of twelve months.

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THE TECHNIQUE OF ILEOSTOMY WITH DESCRIPTION OF A NEW STOMAL CUTTER

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CREATION of a satisfactorily functioning ileostomy has represented a real challenge to those surgeons dealing with ulcerative colitis, multiple polyposis, and allied diseases. Little unanimity[1] exists as to which technique is preferable and the number of fetishes which have arisen is a testimonial to the multiple difficulties this surgery engenders. It is the purpose of this paper to review briefly a technique which has proved itself satisfactory and to present a simple instrument which has facilitated the creation of a trouble-free stoma.

On the day prior to surgery, the ileostomy apparatus† is applied to the abdominal wall so that correct positioning can be assured. The rim of the appliance should not cover the umbilicus and should, likewise, be free of the iliac crest. It should be ascertained that this point will lie conveniently below the belt line. A cross mark is then scratched on the skin denoting the optimum site. When prefitting of the disk is not possible, a point 2 inches down from the edge of the umbilicus and 2 inches directly to the right will usually be found correct and is a site readily visualized and cared for by the patient.

The technique of ileostomy creation is modified from that described by Dennis.[2] After the ileum has been transected through normal tissue, the proximal limb is elevated to assure sufficient mesentary length for transposition through the abdominal wall. To achieve this mobility, the mesoileum is sectioned parallel to the axis of the bowel between the marginal and secondary arcades, carefully preserving the marginal arcade. The ileum is then oversewn with a Parker-Kerr basting stitch, the bowel clamp removed, and the suture ends are drawn tight, tied to each other, and left long.

The right lateral gutter is then closed by suturing the mesentery of the functioning ileum to the lateral and posterior peritoneal walls with interrupted sutures. Clamps are then placed on the anterior rectus sheath and the peritoneum for traction. With one hand beneath the peritoneum of the anterior abdominal wall to provide counterpressure, the ileostomy cutter is carefully centered on the previously marked site, and with a firm turning motion, a cylinder of full-thickness body wall incorporating skin, fat, fascia, and muscle, is excised.

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*Clinical Instructor in Surgery.

†The Paragon apparatus, manufactured by Fazio Laboratories, Auburndale, Mass., has been found eminently satisfactory. Its rubber disk allows cutting of the aperture for correct fitting to the stoma, and the plastic disposable bags permit easy inspection and care of the ileostomy.

The cutter (Fig. 1) is made of stainless steel with a finely ground cutting edge. It has an internal diameter of 2 cm. and an over-all length of 8 cm. Experience has shown that this diameter is not likely to produce the stenosis which may occur with a stab incision through the abdominal wall. The knurled external surface allows easy control in the gloved hand. The cylinder of tissue removed by its use is illustrated in Fig. 1.

The aperture is then inspected for bleeders and those present are clamped and tied. Few, if any, are usually encountered. Six Atraumatic sutures of 5-0 arterial silk are then placed radially through the cut edge of the peritoneum and laid on the anterior abdominal wall. The proximal ileal stump is drawn through the circular wound by the sutures, which were left long for this purpose.

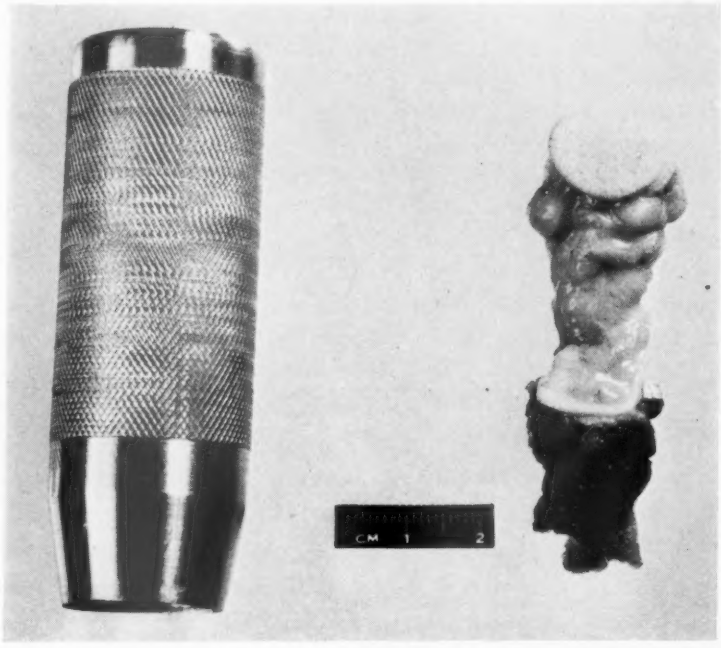

Fig. 1.—The stomal cutter (*left*) is made of stainless steel and has an internal diameter of 2 cm. The cylinder of tissues (*right*) removed by its use in an actual case is illustrated. The various layers of the abdominal wall are clearly seen.

Careful inspection is made to be certain that the ileum lies comfortably and without tension intra-abdominally. The 5-0 silk sutures are then placed in the serosa of the ileum at a level permitting 3 to 5 cm. of the ileum to be above the level of the skin. These sutures are carefully placed through serosa only and tied down without tension.

With the abdomen open and sterility maintained, the basting suture is removed and an 18 Fr. soft, multiperforated, rubber catheter is passed under direct vision through the stoma and past the point of fixation to the abdominal wall. The catheter is then secured to the stoma by two catgut purse-string sutures. The remainder of the operative procedure is then completed and suture of the abdomen is performed from a closure table. A dressing of wet, fine-mesh gauze is applied to the ileostomy base with fluff dressings for further protection.

On return to the ward, the ileostomy catheter is attached to a collection bottle with a long length of rubber tubing. The ileostomy is inspected frequently to ascertain the color and quality of the stoma. To this end, it has been advantageous to place over the fluff dressings a firm-walled, cardboard box whose lid is hinged at one margin. The catheter is then drawn through the lid and the box is fastened into place with adhesive tape. Frequent inspection is facilitated without change of dressing.

A satisfactory seal of ileum to abdominal wall has usually taken place by the fifth postoperative day. The catheter will usually be free and can be removed by the fifth to seventh postoperative day. The ileostomy disk is then cut to fit the ileum without impingement and glued to the abdominal wall. Gentle dilatation of the stoma is initiated by the surgeon on the seventh day and, after careful indoctrination, dilatation is performed by the patient. The ileostomy output is accurately recorded and replacement is carried out on a twelve-hour basis.

SUMMARY

The technique of producing a satisfactory ileostomy has been presented in detail. An instrument which facilitates the cutting of a cylindrical aperture for the ileostomy has been described. This procedure has been followed for both the creation of a functioning ileostomy and for the creation of an ileal bladder. It has materially reduced the hazard of ileal stricture in the abdominal wall and at the skin level.

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A CRITIQUE ON THE THERAPEUTIC VALUE OF LUMBAR SYMPATHECTOMY

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THE therapeutic value of lumbar sympathectomy has been the subject of numerous reports since Royle[1] introduced the operation thirty years ago. Despite this wide experience, there remains considerable doubt concerning the benefit to be expected in individual instances. Investigations in many animal laboratories have shown predictable physiologic changes in the blood flow of a sympathectomized extremity which would suggest probable benefit when applied to the patient. All too often, however, the clinical result has been disappointing.

There are excellent studies to suggest why such disappointments might occur.[2-10] Pye-Smith,[2] Langley,[3] Smithwick,[4] and others[5-8] have demonstrated the ability of sympathetic nerve fibers to regenerate and resume function after wide excision. Smithwick[4] and Fatheree[5] presented evidence to support the thesis that denervated extremities can show hyperreactivity to circulating epinephrine and, for a time, felt that this phenomenon might explain certain sympathectomy failures. Lowenburg and Morton[9] emphasized the difficulty in producing a complete surgical sympathectomy by demonstrating the wide anatomic, and presumably functional, variations in human lumbar sympathetic chains. Independent sympathetic pathways persisting after a standard sympathectomy have been shown to exist by Kuntz and Alexander.[10]

It is probable. however, that sympathectomy failure is related less to anatomic or physiologic aberration than it is to the vagaries of the occlusive disorder in the vessels of the limb under treatment.

This report concerns an effort to evaluate therapeutic results in 192 patients treated by lumbar sympathectomy at The Johns Hopkins Hospital between 1946 and 1951, and followed for a minimum of two years. Of particular interest has been the use of laboratory tests to predict the therapeutic result.

METHOD

All patients who underwent lumbar sympathectomy in The Johns Hopkins Hospital from 1946 through 1951 form the group for study. The only exclusions were those in whom sympathectomy was performed as part of a thoracolumbar ganglionectomy in the treatment of hypertension, and those whose recorded history was grossly inadequate for the purposes of this study. Whenever possible, follow-up was carried out by return visits to the Vascular Clinic or Private Outpatient Departments of this institution, where the majority of patients

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were seen by us. When this was not feasible, reports were obtained by the use of a detailed questionnaire sent to each patient or his personal physician. This questionnaire was designed to give as much objective information as is possible with such a device, as well as to include the patient's subjective response to the operation.

The group adequately followed is divided into 100 ward cases and 92 private cases.

Sympathectomy was carried out by the anterior muscle-splitting, extraperitoneal approach in most cases. In the great majority, the surgeon attempted to remove the second through the fourth lumbar ganglia. More recent attempts to extend the proximal level of sympathectomy, as recommended by Lindstrom[11] and Lilly,[12] have not been evaluated as yet, but show some promise.

In order to facilitate the appraisal of the patients and the result of therapy, certain criteria were established on a somewhat arbitrary basis:

A. The variety of complaints were sifted into those few which could be most accurately evaluated, and which usually were the principal complaint of the patient. Thus, intermittent claudication, rest pain, and tissue necrosis were the only factors considered in the peripheral arterial diseases. Intractable edema was also included in the consideration of the post-thrombophlebitic group.

B. The lower extremities of each patient were evaluated separately. Results as given are based on individual extremities, not upon individual patients.

C. The recorded pulses are those felt most distal in the extremity. No consideration was given as to the vigor of that pulse.

D. The evaluation of the patient's complaints and the status of his extremities was based on the recorded description as noted during his first thorough inpatient examination prior to surgery.

E. The definition of "tissue necrosis" as used in this report includes *any* form of tissue death from minute superficial eczematoid ulceration to frank gangrene.

F. "Amputation," as hereinafter referred to, means major amputation, either transmetatarsal or more extensive. The many toe amputations included in this group of patients are not considered as evidence of a poor sympathectomy result.

G. In 88 per cent of the extremities studied, lumbar sympathectomy was verified by microscopic demonstration of sympathetic ganglia and nerve fiber in the removed specimen. In the remaining 12 per cent pathologic specimens were not sent to the laboratory, but sympathectomy was verified by either postoperative studies of skin resistance[13] or clinical evidence of a warm, dry foot in contrast to its preoperative state.

H. Two years was arbitrarily chosen as the minimum period of observation. The follow-up was based on certain factors which were meant to give the operation of lumbar sympathectomy every chance to "prove itself." Thus, any improvement, regardless of degree, in exercise tolerance, rest pain, or edema, which did not remiss within the two-year period, was considered a good result. If healing of areas of tissue necrosis occurred within two years, with or without associated grafts, venous ligations, or "minor" amputations, it was likewise considered a good result.

MATERIAL

The study includes 251 patients of which 192 were adequately followed for a minimum period of two years. The great majority have been followed for four- and five-year periods.

The total group of 251 was evaluated from the standpoint of operative mortality and postoperative complications. The series of 192 which was adequately followed represents 272 extremities subjected to operation, and forms the basis for the statistical appraisal of therapeutic results.

RESULTS

In this series, the preoperative studies of skin resistance were of no aid in predetermining the likelihood of a good result from sympathectomy. Preoperative evidence of sympathetic hyperactivity in a portion of the affected

limb did not necessarily indicate a better postoperative result. This was equally true of those limbs which showed a "spontaneous sympathectomy" pattern (most commonly in the diabetic group) and were sometimes followed by good results after surgery. The skin resistance test had its greatest usefulness in checking the level of complete sympathectomy postoperatively.

Similarily, prognosis could not be judged from the level of the most distal palpable pulses. A study of 168 extremities in the arteriosclerotic and the diabetic arteriosclerotic groups showed no helpful correlation between the presence of pedal pulses and the expected postoperative result. In fact, in the diabetic group 50 per cent of those extremities which had pedal pulses present ended in failure, and in the arteriosclerotic group, 62 per cent (Tables I and II).

TABLE I. PROGNOSTIC VALUE OF LOWEST PALPABLE PULSE (ARTERIOSCLEROSIS)

LOWEST PALPABLE PULSE	PATIENTS	GOOD RESULT	POOR RESULT	AMPUTATION
Dorsalis pedis and/or posterior tibial	24	9	15 (62%)	1
Popliteal	17	8	9 (53%)	2
Femoral	44	17	27 (61%)	8
No pulse	8	3	5 (63%)	1

TABLE II. PROGNOSTIC VALUE OF LOWEST PALPABLE PULSE (ARTERIOSCLEROSIS WITH DIABETES)

LOWEST PALPABLE PULSE	PATIENTS	GOOD RESULT	POOR RESULT	AMPUTATION
Dorsalis pedis and/or posterior tibial	18	9	9 (50%)	4
Popliteal	29	10	19 (66%)	16
Femoral	19	2	17 (89%)	12
No pulses	9	1	8 (89%)	3

The diabetic group shows a less favorable prognosis with progressive loss of distal pulsations, but this does not hold true for the arteriosclerotic group. It would appear that the presence of pedal pulses is of small value in evaluating an individual prognosis.

The hospital mortality for the 251 patients (364 treated extremities) was 1.2 per cent. All deaths occurred among patients with diabetes, and included one death from bacterial endocarditis two days following operation; one death from coronary thrombosis two days postoperatively; and one death from rapidly extending gangrene of the lower extremity, twenty-eight days after operation. Significant morbidity was seen in 3.1 per cent of the whole group, with such complications as postoperative thrombophlebitis (two), "paradoxical gangrene" (two), wound infection (two), nonfatal pulmonary embolism (one), and postoperative hemorrhage (one). No patient complained of disturbances of sexual function which could be related to the operation.

Arteriosclerosis.—Table III shows the results of the study in the arteriosclerotic group. The average age in this series was 60 years, with a range from 40 to 81 years. Men outnumber women 6 to 1. There were no deaths. Postoperative complications included two cases of postoperative thrombophlebitis, and one case of so-called "paradoxical gangrene." (A thorough study of the patients in whom gangrene developed immediately after surgery produced no conclusive evidence to support Atlas[14] and Freeman's[15] theories of the opening

of proximal intramuscular arteriovenous shunts as causative factors in the phenomenon. We would tend to agree with others[16] that the appearance of tissue necrosis in the immediate postoperative period is probably coincidental to recent major occlusive arterial changes which were unrecognized.)

TABLE III. ARTERIOSCLEROSIS

Follow-up		63 patients	93 extremities
Preoperative Complaints		Extremities	Per cent
Intermittent claudication		78	84
Rest pain		30	32
Tissue death		18	20
Postoperative Results			
Improved exercise tolerance		28	36
Relief of rest pain		13	45
Healing of tissue		6	33
Amputations		13	14
With tissue death at first examination	9		
Without tissue death at first examination	4		
Final Evaluation		Patients	Per cent
Satisfactory		23	37
Unsatisfactory		37	59
Doubtful		3	5

The "final evaluation" of the patients in Table III is an attempt to indicate whether or not the operation produced satisfactory benefit to the patient as a whole. This addendum is deemed necessary, as many patients might have had some relief of one symptom but of none of the others, and, as individuals, felt that the operation was a failure. It should be reiterated here that any benefit of doubt as to success was given to the operation. Those classified as "doubtful" had a good result in one extremity, a poor result in the other.

TABLE IV. ARTERIOSCLEROSIS COMPLICATED BY DIABETES MELLITUS

Follow-up		53 patients	80 extremities
Preoperative Complaints		Extremities	Per cent
Intermittent claudication		25	31
Rest pain		44	55
Tissue death		40	50
Postoperative Results			
Improved exercise tolerance		7	24
Relief of rest pain		12	27
Healing of tissue		8	20
Amputations		35	44
With tissue necrosis at first examination	24		
Without tissue necrosis at first examination	11		
Final Evaluation		Patients	Per cent
Satisfactory		12	22
Unsatisfactory		39	74
Doubtful		2	4

Arteriosclerosis Complicated by Diabetes Mellitus.—Those patients with arteriosclerosis complicated by diabetes mellitus are considered as a separate series, and are summarized in Table IV. The average age in this group was 57 years, with a range from 36 to 75 years. The male to female ratio was 1.6 to

1. Mortality rate among the diabetics reached 4.2 per cent, and is detailed previously. Two wound infections and one "paradoxical gangrene" constituted the only significant postoperative complications.

All the patients with evidence of tissue necrosis or infection received antibiotics during their hospital stay.

It is apparent from this that diabetes significantly reduces the likelihood of a good result from lumbar sympathectomy. Tissue necrosis of any degree in the diabetic arteriosclerotic is an extremely unfavorable situation, even with good antibiotic coverage. Of those diabetics who did not heal minor necrotic areas, 75 per cent came to major amputation within two years despite the sympathectomy.

Buerger's Disease.—Thromboangiitis obliterans was seen in 33 extremities, but only 13 of these were adequately followed. The average age of the group with Buerger's disease was 43 years, with a range from 30 to 60 years. All were men. Symptoms had been present for an average of 4.5 years. There was no operative mortality in the series. The only significant postoperative complication was a nonfatal pulmonary embolism in one patient.

TABLE V. BUERGER'S DISEASE

Follow-up	7 patients	13 extremities
Preoperative Complaints	Extermities	Per cent
Intermittent claudication	8	61
Rest pain	13	100
Tissue death	6	46
Postoperative Results		
Improved exercise tolerance	1	12
Relief of rest pain	4	30
Healing of tissue	2	33
Amputations	3	23
(50 per cent of all with tissue necrosis at first examination)		
Final Evaluation	Patients	Per cent
Satisfactory	2	29
Unsatisfactory	5	71

Postphlebitic Syndrome.—The results of treatment of the postphlebitic syndrome are summarized in Table VI. The average age in this group was 46 years, with a range from 21 to 74 years. Average duration of symptoms was nine years. As many men as women were treated. No mortality was associated with this group. One patient was complicated by a late sizable retroperitoneal hemorrhage.

Of the four patients who healed their ulceration following sympathectomy, one had concomitant high-low venous ligations, two had split-thickness skin grafts, and one had skin grafts plus a superficial femoral venous ligation. Of the whole group, 72 per cent had had one form or another of associated surgical procedures in an attempt to improve the circulatory status or skin coverage of the leg.

Causalgia and Acute Trauma.—Causalgia and acute trauma are briefly considered in Table VII. The causalgia followed massive crushing injuries to the lower extremities in all three patients.

The good result in the popliteal artery suture appeared to be due to the sympathectomy. Immediately following the primary suture, and for two hours thereafter, no distal pulse was felt in the foot. At that time, sympathectomy was carried out, with concomitant return of a warm, dry foot and the presence of pedal arterial pulsation.

Miscellaneous.—A final group of sympathectomized extremities was followed, and is tabulated under "miscellaneous" lesions in Table VIII. Nearly all these operations were carried out during the early years of the time span

TABLE VI. POSTPHLEBITIC SYNDROME

Follow-up	42 patients	53 extremities
Preoperative Complaint	Extremities	Per cent
Intractable edema	39	73.0
Pain	30	56.0
Tissue death	32	60.0
Postoperative Results		
Relief of edema	9	23.0
Relief of pain	9	30.0
Healing of tissue	4	13.0
Amputations	1	1.8
Final Evaluation	Patients	Per cent
Satisfactory	10	24.0
Unsatisfactory	30	71.0
Doubtful	2	5.0

TABLE VII. CAUSALGIA AND ACUTE TRAUMA

Causalgia		
3 patients (3 extremities)		All completely relieved
Acute Trauma		
5 patients (5 extremities)		
Popliteal artery suture	2	One amputation; one good result
Femoral artery suture	1	Amputation
Embolism to femoral artery	1	Good result
Crush injury to foot	1	Amputation

TABLE VIII. MISCELLANEOUS LESIONS

Follow-up	18 patients	25 extremities
	Lesion	Result
1.	Syphilitic leg ulcer (2)	Poor
2.	Intractable hip pain secondary to carcinoma of bladder	Poor
3.	Phantom limb	Poor
4.	Leg ulcer, scleroderma	Poor
5.	Claudication secondary to hypoplastic aorta	Poor
6.	Meralgia paresthetica	Poor
7.	Leg ulcer, sickle-cell anemia	Poor
8.	Right lower quadrant pain following appendectomy	Poor
9.	Leg ulcer, traumatic	Poor
10.	Lymphedema, nonspecific	Poor
11.	Leg ulcer, posterysipelas	Poor
12.	Atrophia dermatitis diffusa	Poor
13.	Foot pain, postsubdural hematoma	Good
14.	Leg ulcer, livedo reticularis	Good
15.	Pelvic pain, hip pain, carcinoma of cervix	Good
16.	Ergot poisoning	Good
17.	Trophic ulcer, poliomyelitis	Good

included in this study, and most represent attempts to apply sympathetic denervation in a relatively "blind" fashion to intractable lesions. As can be seen from the Table VIII, and as subsequent experience has emphasized, there is little indication for sympathectomy in nonspecific lesions such as those listed.

DISCUSSION

The permanent value of lumbar sympathectomy is, of course, impossible to appraise accurately by any such study as the foregoing. What the operation might have done in forestalling the inevitable sequelae of the degenerative occlusive or vasospastic disease affecting the lower extremities is uncertain without corresponding control series of nonoperated patients. Such comparable series are unattainable at present. The problem is further complicated by our inability to relate clinical or laboratory signs to the pathophysiology of these disorders, and their widely variable rate and extent of occlusive changes or vasospastic element in a particular patient.

The direct surgical approach to the occlusive disease forms, at the present time, one of the most widely discussed subjects in surgery. The re-establishment of blood flow down the primary arterial course is obviously the most desirable surgical objective. The excision of diseased coats of arteries with linear resuture as recommended by dos Santos[17] or actual excision of diseased whole segments of arteries with replacement by homograft or plastic prostheses are receiving extensive trial. The latter procedures show great promise and justly deserve their increasing applications to arteriosclerosis. These methods are applicable only when the disease process is segmental, not diffuse. It is not yet known how soon the development of thrombosis will be in these grafts, how extensive the deposit of plaques will be, or if aneurysm will develop in a significant number. The immedate limb mortality and the patient mortality are not yet completely evaluated.

The indirect surgical attack on organic peripheral vascular disease, that of sympathectomy, is a flanking and not a frontal attack. It carries, however, no threat of limb loss, and almost no threat to the patient's life. Many of the patients who have had good results from sympathectomy have maintained their improvement throughout the period of several years, and have undoubtedly been rehabilitated in a gratifying fashion.

However, it is quite apparent that sympathectomy, as practiced in this series, has proved an unsatisfactory therapeutic measure in from 59 to 74 per cent of the cases of arterial occlusive disease, and in 71 per cent of the postthrombophlebitic patients. Such results, coupled with our inability to give any patient a reasonable prediction of the result before subjecting him to the operation as a routine procedure, can hardly be supported with much enthusiasm, and would urge a more vigorous approach to the patient with occlusive disease of the extremities. The wider use of arteriography will enable a more basic attack on certain selected cases. In those whose occlusive changes are too extensive for replacement procedures, the operation of lumbar sympathectomy still holds a valuable place in the surgical armamentarium.

SUMMARY

1. A series of 192 patients, representing 272 extremities which underwent lumbar sympathectomy for various disorders, is presented and evaluated.

2. Predicting the result of operation for an individual patient has been impossible by any clinical or laboratory procedure used for preoperative evaluation in this series. This included the presence or absence of pedal pulses and the use of the skin-resistance test.

3. Poor results of sympathectomy are noted in 59 to 74 per cent of all patients with arteriosclerosis, arteriosclerosis complicated by diabetes mellitus, Buerger's disease, and the postphlebitic syndrome. The presence of any tissue necrosis decreased the likelihood of a good result.

4. The operative mortality in 251 patients (364 extremities) undergoing lumbar sympathectomy was 1.2 per cent. All deaths occurred among patients with diabetes mellitus.

5. It is urged that in the light of these results, a more vigorous attempt be made to screen patients for possible direct attack on the offending occlusion.

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CARCINOMA OF LARYNX WITH CONCURRENT OR SUBSEQUENT DEVELOPMENT OF BRONCHIAL CARCINOMA

Report of Five Cases, With Autopsy Findings

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MULTIPLE tumors of the respiratory tract are uncommon, with the exception of multiple and recurrent laryngeal, tracheal, and bronchial papillomas, a few of which have been reported to have undergone malignant changes.[1-3] This is in contrast to the not infrequent development of multiple carcinomas of the urinary tract and colon, which are of sufficient frequency to demand clinical concern and routine follow-up studies.

In reviewing a series of twenty cases of laryngeal carcinoma which have come to autopsy at Coral Gables Veterans Administration Hospital during the past four years, five patients were found to have developed a concurrent or subsequent bronchogenic carcinoma (Table I). All were white men, ages ranging from 52 to 73, and all were cigarette smokers. In three patients, the laryngeal and bronchial tumors were diagnosed either simultaneously or within a short interval of time; in two cases, the laryngeal preceded the bronchial tumors, one by seven months, the other by seven years; both of these patients had intrinsic laryngeal tumors confined to one vocal cord. All laryngeal carcinomas were squamous-cell types. In three cases, the bronchial differed from the associated laryngeal carcinomas microscopically, consisting of anaplastic tumor cells. The remaining two were squamous-cell carcinomas, closely resembling the associated laryngeal tumors. Survival after diagnosis of laryngeal tumors ranged from seven months to seven years. Autopsy in all cases revealed multiple visceral metastases. There are five additional similar cases in the records of this hospital, which are not included in the study either because autopsies were not performed or because the patients are still living.

Warren and Ehrenreich,[4] in a study of 2,829 consecutive autopsies, found 194 cases of multiple tumors, only two of which involved both larynx and lung. Cahan, Butler, Watson, and Paul[5] reported a study of 1,493 cases of bronchogenic carcinoma, four of which were found to have synchronous laryngeal carcinomas. A further investigation by Cahan[6] of 2,502 primary lung carcinomas showed nineteen cases which also had laryngeal carcinomas; of the latter, eight were intrinsic, eleven of extrinsic type anatomically. Histologic comparison between the bronchial and laryngeal tumors was made only in Cahan's first report (1950), and in all four cases the tumors were of squamous-cell type. Willis[7] cited a case described by Von Zalta in 1943 in which a

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squamous-cell carcinoma of the larynx was associated with multiple intrabronchial carcinomas. Aubin, Ebstein, and Neveu[8] in 1953 reported a case of squamous carcinoma of the larynx, with laryngectomy, which was followed four years later by a squamous carcinoma of the right bronchus, with superior vena caval syndrome and multiple visceral metastases.

TABLE I. SUMMARY OF CASES OF LARYNGEAL AND BRONCHIAL CARCINOMA

	CASE 1	CASE 2	CASE 3	CASE 4	CASE 5
Age	73	57	60	60	52
Synchronous laryngeal and bronch. ca.	X	--	X	--	X
Metachronous interval laryngeal to bronchial ca.	--	7 mo.	--	7 yr.	--
Location laryn. ca.	Extr.	Intr.	Extr.	Intr.	Extr.
Hist. type laryn. ca.	Squamous	Squamous	Squamous	Squamous	Squamous
Hist. type bronch. ca.	Anaplastic	Anaplastic	Squamous	Squamous	Anaplastic
Location bronch. ca.	R. main RUL	LUL	RLL RUL	LUL	LUL
Therapy laryn. ca.	Surg.	Surg.	Irrad. Surg.	Surg.	Irrad.
Survival (years)	2½	3¼	7/12	7	2½
Metastases	Heart L. Adrenal	Heart Liver Adrenals Nodes	Heart Liver Pancreas Adrenals Nodes Kidneys Prostate	Heart Liver L. Adrenal Bones Nodes	Adrenals Nodes

As is evident in the following case reports, an intrathoracic tumor discovered during or after demonstration of a laryngeal carcinoma was frequently interpreted as a metastatic lesion and treated as such.

CASE 1.—A 73-year-old white man was admitted to the hospital because of intermittent hoarseness of two years' duration. Laryngoscopic examination revealed a fungating tumor mass involving the left true and false cords and extending distally for a distance of 3 cm. Biopsy showed squamous-cell carcinoma. Admission chest roentgenogram showed an infiltrating process in the right upper lobe. Originally thought to be inflammatory, this process was felt to be neoplastic on subsequent examinations. Bronchoscopic examination was then made and a tumor involving the anterior and lateral portions of the right main stem bronchus was seen. Biopsy showed carcinoma, predominantly anaplastic in type. Total laryngectomy was advised, to be followed later by a surgical attempt to remove the bronchial tumor. A laryngectomy was carried out but it was felt later that pneumonectomy was inadvisable because of the proximity of the bronchial tumor to the trachea. The patient was readmitted four months after laryngectomy with x-ray evidence of considerable enlargement of the lung tumor, weight loss, and dysphagia, and he expired after a rapidly downhill course. Duration of life after laryngectomy was six and one-half months; after onset of symptoms, approximately two and one-half years. Autopsy revealed two endobronchial tumor masses in the right main bronchus, one immediately distal to the carina, another arising 1.5 cm. distally. The right upper lobe and adjacent pleura were largely replaced by tumor. There were

secondary nodules in the wall of the left auricle and right adrenal gland. The mucosa of the tracheal stoma showed small foci of carcinoma. Microscopically, the bronchial tumor and metastases were an anaplastic type.

CASE 2.—A 57-year-old white man was first seen because of progressive hoarseness for one year. Under direct laryngoscopy a mass was seen to involve the posterior portion of the right vocal cord, biopsy of which revealed squamous-cell carcinoma. A total laryngectomy was performed, sections showing minimal infiltration of submucosa by tumor. Pre- and postoperative radiographic studies showed no evidence of metastatic disease. The patient was seen thereafter at intervals by the Tumor Board, and seven months after laryngectomy, a chest roentgenogram showed infiltrations of the left upper lobe, right upper lobe, and left hilar areas. Bronchoscopic examinations, cytologic study of sputa and bronchial secretions, and left scalene node biopsy failed to establish the presence of tumor. However, he ran a slowly downhill course with development of left pleural effusion, hemoptysis, hepatomegaly, and a left-sided Horner's syndrome. Roentgenogram studies showed steady enlargement of the pulmonary masses. He expired twenty-one months after laryngectomy, thirty-three months after onset of laryngeal symptoms. Autopsy showed an anaplastic type carcinoma of the left upper lobe bronchus, with extension into parenchyma of left upper and lower lobes, visceral and parietal layers of pericardium, myocardium and hilar lymph nodes, and metastases to liver, both adrenals, and retroperitoneal lymph nodes. All metastases were of an anaplastic type.

CASE 3.—This 60-year-old white man was admitted with known laryngeal carcinoma, diagnosis having been established seven months previously at another hospital. He had been treated by irradiation, and tracheotomy and tube-feeding had become necessary. On admission, a large fungating tumor within the larynx was visualized and several large, hard cervical lymph nodes were present. Biopsy of the laryngeal tumor showed squamous-cell carcinoma, Grade III. A chest roentgenogram showed no metastatic lesions and visualization of the esophagus revealed no obstruction. A total laryngectomy, thyroidectomy, and right radical neck dissection were carried out. The surgical specimen revealed a large destructive carcinoma involving both vocal cords, extending proximally into the epiglottis, and distally along the trachea, involving the right lobe of the thyroid gland and deep cervical nodes on the right. The patient expired on the eighth postoperative day. Autopsy showed two tumors involving the mucosa of the right lower lobe bronchus, both annular in configuration, the proximal mass 1 cm. distal to the ostium of the bronchus, the other situated 2 cm. disal to the first. The latter was continuous, with submucosal tumor infiltrating and elevating the mucosa for a distance of 1.5 cm. distally. In the posterior segmental bronchus of the right upper lobe a similar annular tumor mass was found. All bronchial tumors were squamous carcinomas, similar in histology to the laryngeal tumor. In all sites there was invasion through the bronchial walls into lung parenchyma. All lobes and pleura had small nodules of metastatic tumor. There were numerous large metastases in myocardium, liver, pancreas, both adrenals, mediastinal and retroperitoneal lymph nodes, both kidneys, and prostate. All metastatic lesions maintained a close similarity with the laryngeal tumor.

CASE 4.—A 60-year-old white man was admitted with a history of right hemilaryngectomy for squamous-cell carcinoma six years previously. This had recurred three times during the following three years, but only local surgical excisions had been necessary. There was also a history of recurrent renal calculi, with left nephrectomy, right nephrolithotomy and subsequent right-sided chronic pyelonephritis. On admission to this hospital six years after the original laryngeal operation, for treatment of urinary tract infection, chest roentgenograms revealed emphysema and minor nonspecific foci of fibrosis. One year later he was admitted because of productive cough and left chest pain. A chest x-ray revealed a mass lesion involving the left upper lobe, suggesting bronchogenic carcinoma. Bronchoscopic examination revealed stenosis of left upper lobe bronchus. Biopsy, as well as cytologic studies of bronchial secretion and sputum, failed to substantiate the presence of a tumor. A left exploratory thoracotomy was performed, and a large tumor involving left upper lobe, pleura, and

mediastinal nodes was found. The lesion was considered inoperable and a hilar lymph node was removed and found to be replaced by squamous carcinoma. There was a slow downhill course, complicated by the renal infection. The patient expired four months after thoracotomy, seven years after diagnosis of laryngeal carcinoma. Autopsy showed squamous carcinoma originating in left upper lobe bronchus, almost completely replacing left upper lobe and invading pleura, pericardium, and mediastinal lymph nodes, and metastasizing to liver, left adrenal, retroperitoneal lymph nodes, lumbar vertebrae, and ribs. No tumor was found in the larynx or other cervical structures.

CASE 5.—This 52-year-old white man was first seen because of difficulty in swallowing and pain in left neck of two months' duration, and sore throat and hoarseness of one month's duration. Laryngoscopic examination showed a tumor mass involving the left side of the epiglottis, extending to, but not including, the vocal cords; fixation of arytenoid folds was noted. Biopsy showed squamous-cell carcinoma, Grade III. A chest roentgenogram showed a mass in the left upper lung field. The patient was treated by irradiation, 3,250 r to each side of the neck. It was felt that only palliation was accomplished. He was readmitted one year later because of dysphagia, throat pain, and difficulty in breathing caused by excessive mucus in the throat. Laryngoscopic examination showed a tumor which almost occluded the larynx. A tracheotomy was carried out immediately. X-ray examination of the chest revealed that the mass in the left lung had increased greatly in size during the past year. Hard, enlarged right cervical nodes were also present. He was treated palliatively and six months later a feeding gastrostomy was carried out because of inability to swallow. The course was slowly downhill and he expired two and one-half years after onset of symptoms. A chest x-ray one month before death showed progressive enlargement of the mass in the left lung, the tumor at that time filling the entire mid-portion of the left lung field. Autopsy revealed a necrotic, fungating laryngeal tumor which had destroyed laryngeal walls and epiglottis and invaded the pyriform sinuses and the base of the tongue. The left upper lobe of lung was almost completely replaced by tumor which appeared to originate in the left upper lobe bronchus. Secondary tumor was present in the adrenals, cervical lymph nodes, and thyroid. Microscopically the laryngeal tumor was of the squamous variety, and the bronchial tumor was an anaplastic type. The thyroid gland was invaded by the squamous carcinoma. The adrenals and the cervical lymph nodes showed an anaplastic tumor similar histologically to the bronchial carcinoma.

DISCUSSION

Of considerable interest and importance is the question of the etiological relationship between the laryngeal and bronchial tumors. A number of possibilities are to be considered: (1) the laryngeal and bronchial tumors are separate and distinct, with no relation except through a common carcinogenic agent; (2) bronchial tumors in such situations may represent attachment and growth of tumor cells aspirated from the higher primary focus; (3) bronchial tumors may be true metastases from primary laryngeal carcinomas; (4) some cases suggest the possibility of a bronchial primary site, with the laryngeal tumor representing a metastatic lesion or a retrograde surface implantation.

1. If multiple carcinomas of the respiratory tract epithelium are to be considered separate primary tumors, rather than implants or metastases, one from the other, then it must be suspected that a carcinogenic agent has been acting upon sensitive epithelial surfaces, with development of multiple foci of neoplasia. According to the "field theory" of carcinogenesis,[9] areas of atypical epithelial hyperplasia, metaplasia, preinvasive carcinoma, or fully developed carcinoma, may be found at various localities in the respiratory tract in such

cases, if survey studies were made. Statistical studies have been explored to establish a possibly significant correlation of the incidence of various respiratory tract tumors.

The series presented here is obviously too small to allow statistical analysis. A study by Maxwell[10] in 1955 showed that carcinoma of the larynx had not increased in frequency during the same period that vital statistics in Great Britain showed a great rise in the incidence of bronchogenic carcinoma. He concluded that inhaled carcinogenic agents, if responsible for bronchial malignancies, apparently had no significant effect upon the laryngeal epithelium. Sadowsky, Gilliam, and Cornfield[11] in 1953 stated that their statistics showed some correlation between cigarette smoking and laryngeal cancer; however, they admitted that there has been no increase in the incidence of this tumor in any way comparable to that of bronchogenic carcinoma; and they further stated that if cigarette smoking is of significance in the etiology of bronchogenic carcinoma, then it must be explained why there has been no corresponding increase in laryngeal carcinoma. Likewise, Kennaway and Kennaway[12] in 1951 stated that the increased consumption of tobacco apparently does not correlate with the incidence of laryngeal carcinoma, and that vital statistics for the fifteen years prior to 1951 showed a decrease in laryngeal carcinoma in men with the incidence stationary in women. However, Baltzell and Putney[13] in 1954 demonstrated a marked increase in laryngeal carcinoma in their clinic, stating that the incidence showed a sevenfold increase during the prior twenty-five years. Of their series of 1,498 patients, 12 per cent were nonsmokers, as contrasted with 38 per cent nonsmokers among the general population. Wynder, Bross, and Day[14] reported in 1955 a direct relationship between the quantity of cigarettes smoked and the incidence of laryngeal carcinoma; they also concluded that heavy use of alcohol apparently makes the laryngeal mucosa more susceptible to the carcinogenic effects of tobacco smoke.

When other inhalants are considered in relation to laryngeal carcinomas, statistical evidence is somewhat scant, beyond the statement by Kennaway and Kennaway[12] that the incidence of cancer of the larynx is higher among those engaged in the retail selling of alcohol, and that urban populations show a higher incidence of laryngeal carcinoma in men and a lower incidence among women than rural district dwellers.

Other carcinogenic agents which have been incriminated in tumor production include various infective agents, especially viruses. There is some evidence that multiple papillomas of the larynx and trachea may be induced by viruses, that similar papillomas may also extend into the bronchial tree, and that on a few occasions these tumors may be true carcinomas.[1-3]

2. In all cases of multiple tumors of a single epithelial tract, the traditional assumption has been that the more distal tumors are implants. Experimental studies, such as those by Furth,[15] have demonstrated the possibility of forcing tumor cells into the lower respiratory tract of animals, and showing that some of these cells attach and propagate in the mucous membrane. Autopsy studies by several workers have demonstrated aspiration of malignant cells from a bronchial carcinoma into tributary bronchi, bronchioles, and alveoli, and apparent

propagation of such cells in the mucosa of the latter structures. Spread of tumors to the contralateral lung has also been ascribed to aspiration. Willis[9] stated that tumors may spread by aspiration through the upper and lower respiratory tracts, although he believed that this occurred only rarely. Ewing[16] expressed doubt as to the occurrence of such aspiration metastases. Von Zalta[7] and Aubin, Ebstein, and Neveu[8] were convinced that their cases demonstrated "metastases by aspiration."

Localization of previously reported bronchial tumors associated with laryngeal carcinomas has not been stated, with the exception of Von Zalta's[7] and Aubin, Ebstein, and Neveu's cases,[8] both of which were in the right lung. If lung abscesses and lipoid pneumonia, both of which are usually secondary to aspiration, may be used as comparable situations, the location is more often in the right lung, more frequently in the upper lobe; the left lower lobe follows in frequency of involvement and left upper lobe is relatively seldom affected.[17] In the cases reported here, the left upper lobe bronchus was the more frequent site of carcinoma, with three cases; two cases involved bronchi of the right lung, one of which had tumor in the right lower lobe.

3. The bronchial tumors may be true metastases, via lymphatic or hematogenous routes. Although various surveys of end results of laryngeal carcinomas, such as that of Latella in 1952,[18] show the incidence of pulmonic metastases to be as high as 6 per cent, it is generally agreed that laryngeal neoplasms seldom produce distant metastases, and secondary tumors are confined usually to regional lymph nodes. Pulmonary metastases, when reported, have been peripheral in location. Endobronchial carcinomas, however, usually are of bronchial origin, although a small portion of them may be metastatic, as shown by Seiler, Clagett, and McDonald,[19] King and Castleman,[20] and Willis.[9] That lymphatic channels from the larynx, above, at, and below the vocal cords, drain only into the deep cervical and tracheal nodes, with no communication with the lungs, has been pointed out by many authors.[21]

While it is well known that metastases do not necessarily reproduce the histology of the primary tumor, a wide and consistent variation between two tumors may with validity lead one to assume that multiple primary tumors are present. It is worthy of mention that of the five cases presented here three showed bronchial carcinomas of an anaplastic-cell type; whereas all laryngeal tumors were squamous-cell carcinomas. Metastases from laryngeal carcinomas, so far as can be determined from the literature and from study of the cases at this hospital, have always rather closely simulated the parent tumors, which have been, with few exceptions, well-differentiated squamous-cell carcinomas. All patients in this report also demonstrated multiple visceral metastases, the gross pattern closely following that of the distribution of bronchogenic carcinomas,[22] with adrenal gland masses in all cases, myocardial deposits in three of five cases, and hepatic involvement in three of five cases. All infraclavicular metastases resembled the bronchial tumors histologically; those in the cervical lymph nodes resembled the laryngeal tumors.

4. Possibility of implants or metastases in the laryngeal mucosa from a bronchial primary may be considered in cases of apparently synchronous tumors.

The normal flow of bronchial secretions, which often contains malignant cells when a bronchial carcinoma is present, is translaryngeal. It is reasonable to believe that the upper respiratory tract mucous membrane is exposed to exfoliated tumor cells to a much greater degree than the bronchial mucosa is exposed to such cells from above, because lower tract malignancies are the more frequent. However, no reported cases of laryngeal or tracheal implants from exfoliated or detached cells from bronchogenic carcinoma can be found in the literature. It may be concluded tentatively that such does not occur, either because the upper tract epithelium is resistant to tumor-cell implantation, the tumor cells in bronchial secretions are not viable or susceptible to implantation when they reach the upper tract, or, finally, that the implantation theory rarely, if ever, applies in the respiratory system. Although bronchogenic carcinomas are known to metastasize widely, often in bizarre fashion, and to involve supraclavicular structures quite frequently, no instances of metastases to laryngeal mucous membrane can be found in the literature. Loughead and Bushnell[23] reported that an extensive search of the literature revealed only five cases of metastatic lesions in the mucous membrane of the larynx, excluding lymphomas; three were melanomas, and two were renal-cell carcinomas. That few cases have been reported may be attributable, however, to the fact that most autopsies do not include examination of the larynx unless demanded by clinical symptoms.

SUMMARY AND CONCLUSIONS

The problem of the management of cases of carcinoma of the larynx with simultaneous or subsequent development of bronchial carcinoma prompted this study of five such patients occurring in a series of twenty autopsied cases of laryngeal carcinoma. The following conclusions are presented:

1. Further studies regarding the relationship of associated laryngeal and bronchial carcinomas may elucidate the etiology of respiratory tract tumors.

2. Patients with laryngeal carcinomas, treated by irradiation or surgery, should be observed closely for possible development of bronchogenic carcinomas.

3. Carcinomas of larynx and bronchus in the same individual should be regarded as separate primary tumors and treated as such.

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ACUTE PNEUMOCHOLECYSTITIS

A Review of the Literature and a Report of One Case

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ACUTE pneumocholecystitis is a rare condition with only thirty-seven cases reported in the literature.

Lobingier[17] in 1908 was the first to report one case of acute pneumocholecystitis. Hegner[13] in 1931 was the first to make the preoperative diagnosis by scout films of the abdomen. McCorkle and Fong[21] in 1942 were the first to make recommendations for the treatment of acute pneumocholecystitis, their opinion being that conservative management was the treatment of choice. Heifetz and Senturia[14] were the first, in 1948, to term the phrase "pneumocholecystitis" for this condition. Qvist[24] in 1951 reported a review of the literature of twenty-five cases with one of his own. Again in 1953, a review of the literature was reported by Bell, Brown, and Lenhardt[2] with a report of two of their own cases. Ryan, Harrigan and Penny[27] reviewed the literature in 1953 and reported one of their own cases; they were the first to recommend surgery as the treatment of choice in this condition.

Thirty-seven cases with a review of the literature are presented (Table I) to which one case of our own is added.

The average age incidence in this series of thirty-eight cases was 56.1 years; the youngest patient reported was 32 years and oldest 75 years. The age incidence parallels the age incidence of acute cholecystitis.

The sex incidence demonstrates a relative reversal when compared with acute cholecystitis. Of the thirty-eight cases there were twenty-six men and twelve women, a sex incidence of 68.3 per cent men and 31.7 per cent women. In a review of 240 cases of acute cholecystitis proved by surgery and histopathology over a ten-year period (1942 to 1952) at Charity Hospital of Louisiana at New Orleans there were 81.7 per cent women and 18.3 per cent men.

Diabetes mellitus was associated with ten cases of thirty-eight reported in Table I, giving an incidence of 26 per cent.

Various organisms have been cultured from the gall bladder and duodenum in this disease process. Duodenal intubation was used to obtain specimens for culture. The most common organism associated with acute pneumocholecystitis has been *Clostridium perfringens;* however, *Clostridium oedemantiens, E. coli,* and various other organisms (Table I) have been isolated from this disease process. The organism isolated in our case was *Clostridium perfringens* as identified by the Department of Bacteriology at Charity Hospital,

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TABLE I

REPORTED BY	TREATMENT	RESULT	AGE	SEX	DIABETES	CULTURE
1. Lobingier,[17] 1908	Cholecystectomy	Rec.	55	M	Yes	Not reported; acc. to spec.
2. Cottam,[4] 1917	Cholecystostomy	Died	41	F	Yes	*B. aerogenes capsulatas*
3. Tanner,[32] 1921	Cholecystectomy	Rec.	44	M	No	*Strept.* and *B. coli*
4. Kirchmayr,[16] 1925	Cholecystectomy	Rec.	64	M	Yes	*C. welchii*, nonspore forming
5. Halle,[12] 1921	Conservative	Died	60	F	No	*Cl. perfringens* at post-mortem
6. Hegner,[13] 1931	Cholecystostomy	Died	62	M	No	Atypical *Cl. welchii*
7. Simon,[30] 1932	Cholecystectomy	Rec.	32	M	No	No culture made
8. Wybauw,[33] 1936	Cholecystectomy	Rec.	53	F	No	None reported
9. Schmidt,[28] 1938	Conservative	Rec.	37	M	No	--
10. Del Campo,[6] 1940	Cholecystostomy	Died	74	M	No	*Cl. perfringens*
11. McCorkle and Fong,[21] 1942	Cholecystostomy	Died	49	M	No	*Cl. perfringens*
12. McCorkle and Fong,[21] 1942	Conservative	Rec.	59	M	No	Duodenal drainage prod. *B. coli*
13. McCorkle and Fong,[21] 1942	Conservative	Rec.	49	M	No	Duodenal drainage prod. organisms resembling *C. welchii*
14. Stevenson,[31] 1944	Cholecystostomy	Rec.	64	M	No	Aerobic and anaerobic streptococci
15. Stevenson,[31] 1944	Cholecystostomy	Rec.	63	F	No	Anaerobic culture not made
16. Stevenson,[31] 1944	Conservative	Rec.	52	M	No	--
17. Pierini,[23] 1945	Cholecystectomy	Rec.	63	F	No	Anaerobic *Cl. bellonansis*
18. Hutchinson,[11] 1946	Cholecystectomy	Rec.	55	M	No	*C. welchii*
19. Heifetz and Senturia,[14] 1948	Cholecystostomy	Rec.	52	M	No	*Strep. fecalis*, paracolon
20. Heifetz and Senturia,[14] 1948	Cholecystostomy	Rec.	57	F	No	*Cl. filaformi*
21. Culver and Kline,[5] 1948	Conservative	Rec.	60	M	Yes	Not reported
22. Jemerin,[15] 1949	Conservative	Died	60	F	Yes	*Cl. oedematiens*
23. Friedman,[8] 1949	Cholecystectomy*	Rec.	53	F	No	No anaerobic culture
24. Friedman,[8] 1949	Conservative†	Rec.	68	M	No	Not reported
25. Friedman,[8] 1949	Conservative‡	Rec.	66	M	Yes	Not reported
26. Friedman,[8] 1949	Conservative§	Rec.	65	M	No	Not reported
27. Qvist,[24] 1950	Cholecystostomy	Rec.	63	M	No	No anaerobic culture
28. Gowdey,[10] 1950	Cholecystectomy	Rec.	57	M	No	Gram-positive gas-forming anaerobic bacillus
29. Elsey and Hudson,[7] 1950	Cholecystostomy	Rec.	75	M	No	*Cl. welchii*
30. Rothbart,[26] 1952	Cholecystostomy	Rec.	63	F	No	*B. coli*
31. Rothbart,[26] 1952	Cholecystostomy	Rec.	51	M	No	Accident to specimen
32. Rocco,[25] 1952	Conservative	Rec.	45	F	No	Culture of duodenal fluid *E. coli*, streptococcus; seven weeks later, surgery culture produced gram-positive rods
33. Schwinger,[29] 1952	Conservative	Rec.	74	F	Yes	--
34. Abel and Rousselot,[1] 1952	Cholecystostomy	Rec.	?	F	No	Negative culture
35. Ryan,[27] 1953	Cholecystectomy	Rec.	70	M	No	Atypical *Cl. perfringens*
36. Bell,[2] 1953	Cholecystostomy	Rec.	56	M	No	No growth on anaerobic culture
37. Bell,[2] 1953	Cholecystostomy	Rec.	55	M	No	*Aerobacter aerogenes*
38. LaCour and O'Neil	Cholecystectomy	Rec.	67	M	Yes	*Clostridium perfringens*

*, †, ‡, §Cases from the records at University of Minnesota reported 1949 and treated January, 1929, March, 1935, December, 1945, October, 1947, respectively.

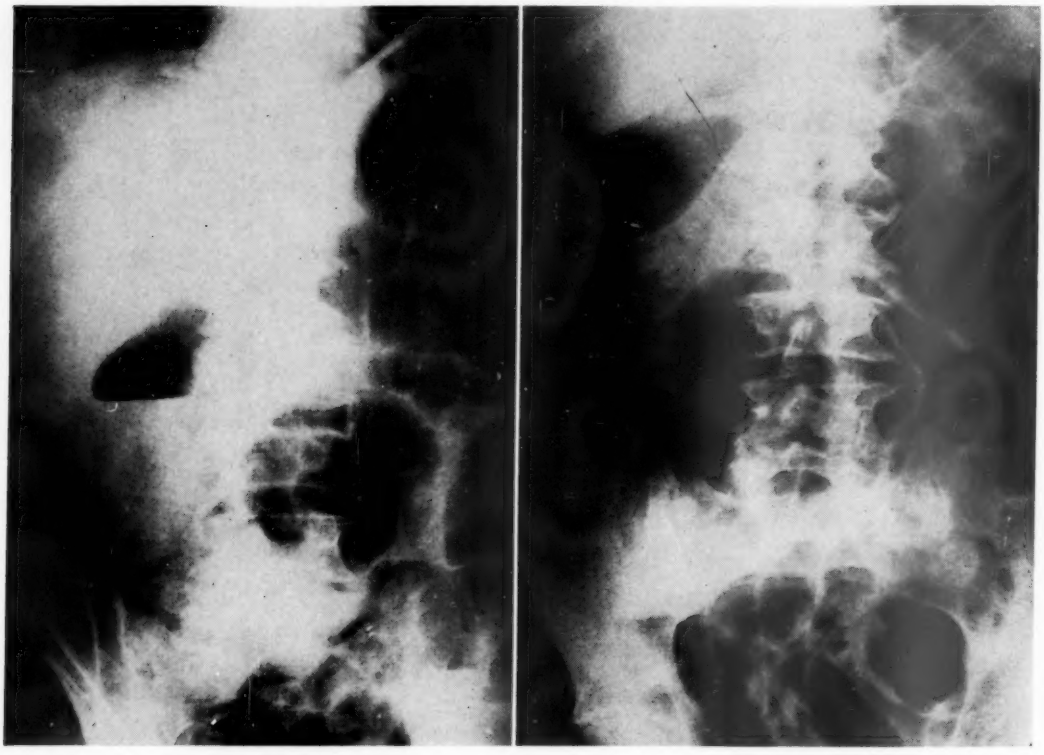
New Orleans, Louisiana, and confirmed by the Department of Public Health, Atlanta, Georgia. The organism in our case was cultured in hydrogen anaerobic cultures in the Department of Bacteriology at Louisiana State University School of Medicine, New Orleans, Louisiana.

Gordon-Taylor and Whitby[9] have demonstrated that in a series of 100 gall bladders at post-mortem approximately 9 per cent of the gall bladders contained *Clostridium welchii*. In a study by Markowitz,[18, 19] reporting on work done by Dragsted and others, he stated that death in animals occurred in 75 per cent of the cases of hepatic artery ligation in the dog; however, with adequate antibiotic coverage the mortality was reduced to 35 per cent, and this mortality was secondary to a gangrenous perforated gall bladder. The protection against liver necrosis and death was achieved by adequate antibiotic coverage. In those cases not protected by adequate antibiotic coverage and resulting in death, the predominant organism cultured in the liver was a gram-positive anaerobic bacillus. This work has been carried into practical application by Reinhoff and others in the ligation of the hepatic artery in the management of bleeding esophageal varices. The application of this finding in this paper is to demonstrate that the liver and bile radicles are a normal habitat for the gram-positive anaerobic organisms. It also becomes evident that once injury is sustained in the biliary system or liver, either due to anoxia or pre-existing infection, this system becomes vulnerable to the growth of anaerobic organisms. It is our opinion that this is the pathogenesis of acute pneumocholecystitis; however, endogenous spread and local extension should also be considered in the pathogenesis of acute pneumocholecystitis. Giving support to the latter opinion, at the time of surgery the colon is frequently found adhered to the gall bladder (without a fistula) and it would seem likely that this could be the mode of extension through retrograde lymphatics to the gall bladder of the offending organism.

The diagnosis of acute pneumocholecystitis is based primarily upon x-ray findings (Fig. 1). The usual picture of acute cholecystitis, namely, nausea, vomiting, right upper quadrant and/or epigastric pain is present. Onset of symptoms is usually less insidious than the symptoms of acute cholecystitis. Increasing toxicity may be the only clinical variant from acute cholecystitis. Abdominal examination findings simulate those of other types of acute cholecystitis; however, in our patient there was minimal edema of the skin in the right upper quadrant. History and physical examination offer nothing as an aid in establishing the diagnosis of acute pneumocholecystitis. The preoperative diagnosis of this condition can only be made by x-ray findings. This fact makes early routine films of the abdomen significant in all cases of acute cholecystitis and particularly for those who would treat acute cholecystitis conservatively. The findings on roentgenograms may not always be present in the first twenty-four hours after onset of illness; however, these findings should always be present within forty-eight hours. Flat plate of the abdomen reveals a large globular, gas-filled gall bladder in the right upper quadrant, and on erect plate this finding is present plus a fluid level. McCorkle and Fong[21] reported that this latter finding on roentgenograms should not be

present; however, in a review of the literature and in our own patient, a fluid level in a gas-filled gall bladder was a constant finding on erect films of the abdomen.

These findings should not be confused with other air shadows or conditions simulating air shadows. Lipomatosis of the gall bladder with a less-than-water density may produce an emphysematous type picture on x-ray examination. Other gas infections in the right upper quadrant may similate acute pneumocholecystitis. Rothbart and Steinberg[26] reported one case of gas infection in a right perirenal abscess. A fistula between the gall bladder and the gastrointestinal tract may allow air to become visible on x-ray examination in the biliary system; however, there should never be any problem



A. *B.*

Fig. 1.—*A*, Erect and *B*, flat plates of the abdomen demonstrating a large gas-filled gall bladder with a fluid level.

in differentiating this condition from other gas shadows in the right upper quadrant. The most significant findings on x-ray examinations in this latter condition are a small, contracted gas-filled gall bladder with or without air in the bile radicles and no fluid level in the gall bladder on the erect plates of the abdomen. Another condition which may produce air in the biliary system is an incompetent sphincter of Oddi.

Cholecystectomy is the treatment of choice in acute pneumocholecystitis when the patient is seen in the first seventy-two hours after the onset of

symptoms. As will be shown in the mortality figures, no other treatment should be considered during this period.

Perforation secondary to gangrene which is secondary to the necrobiotic process of the anaerobic organism is a constant finding in the gall bladder when treatment is delayed. Perforation occurred in eight patients[2, 7, 14, 15, 21, 30, 31] following a delay in surgery of four days to seven weeks and, omitting the two extremes, the average delay was thirteen to sixteen days. The patient's general condition and degree of peritonitis should guide one in the surgical management of perforation of the gall bladder in acute pneumocholecystitis. Cholecystectomy should be performed if the condition of the patient will permit; however, when this is not possible cholecystostomy with adequate antibiotic coverage is the treatment of choice.

Tetracycline is the antibiotic of choice in the management of acute pneumocholecystitis both pre- and postoperatively. Newton and associates[22] in 1955 reported on the sensitivity of ten species of Clostridia to penicillum, Terramycin, Aureomycin, and chloramphenicol, and it was their conclusion that Aureomycin and Terramycin are more effective against these organisms than other antibiotics studied. These studies were on Korean battle casualties in vitro.

The mortality associated with acute pneumocholecystitis is 15.7 per cent with six deaths in the thirty-eight cases reported. Analyzing the deaths in the following groups provides adequate interpretation of the mortality and lends support to the management of these cases as set forth previously. Seven patients[8, 16, 17, 23, 30, 32, 33] were managed during the preantibiotic era without antibiotics and with cholecystectomy representing 18.4 per cent of the total cases. There were no deaths in this group. Average duration of time between onset of symptons and cholecystectomy in this group was five days. Four patients[10, 11, 27] were treated with cholecystectomy and antibiotics, representing 10.5 per cent of the total number of cases reported. Average duration of time between onset of symptoms and treatment was three days. There were no deaths in this group. Four patients[4, 6, 13, 21] were treated with cholecystostomy and without antibiotics. Average duration of time between onset of symptoms and treatment in this group was seven days. There were four deaths in this group representing a mortality of 100 per cent. Diagnosis was established by surgery and post-mortem examination and the offending organism cultured as shown in Table I. Five patients[2, 7, 14] were treated with cholecystostomy and antibiotics, representing 13.1 per cent of the total group. The average duration of time between onset of symptoms and cholecystostomy was ten days while the average duration of time between onset of symptons and treatment with antibiotics was three days, giving an average of seven days' treatment with antibiotics before cholecystostomy was performed. No deaths occurred in this group. Six patients[1, 24, 26, 31] were treated without surgery and no mention of antibiotics was made; however, these patients were treated during the antibiotic era and probably represent a failure to mention drug therapy in the report of their treatment. There were no deaths in this group. Four patients,[8, 12, 28] representing 10.5 per cent of the total number of

cases were treated conservatively without antibiotics. There was one death[12] reported in this group and this was shown at post-mortem examination to represent acute pneumocholecystitis. At this point it is difficult to understand how any patient can recover without the aid of surgery or antibiotics or a combination of the two. For this reason, in those cases treated conservatively without antibiotics in which recovery was uneventful, we wonder if some other condition producing air in the biliary system was not present. Eight patients[5, 8, 15, 21, 25, 29, 31] were treated conservatively with antibiotics. The average duration of time between onset of symptoms and treatment in this group was three and one-half days. There was one death[15] in this group, or a 10 per cent mortality.

Summarizing the deaths, the patient reported by Jemerin[15] was treated conservatively for fourteen days with improvement and at this time an elective cholecystectomy was performed. The patient subsequently died with *B. coli* septicemia, possible cardiovascular disease multiple pulmonary emboli and right pyelonephritis. The death reported by Hegner[13] was treated for ten days prior to surgery and at surgery there was multiple abscess about the gall bladder with perforation of this structure. The patient died and at post-mortem examination a pulmonary embolus was demonstrated. The death reported by Halle and Marquezy[12] in 1922 was the first case reported which was managed conservatively and the patient died twelve days following the onset of symptoms. At post-mortem examination there was air in the peritoneal cavity and a gangrenous gall bladder with perforations. Culture of the gall bladder produced *Clostridium perfringens.* Del Campo and Otero[6] reported one death with a duration of symptoms five days prior to surgery, and the patient died four days following surgery. The patient had a cholecystostomy and no antibiotics were given. McCorkle and Fong[21] reported one death following cholecystostomy with no antibiotics and a duration of symptoms three days prior to surgery. The patient died on the first postoperative day and post-mortem examination revealed evidence of extensive emphysema of abdominal and thoracic walls surrounding the incision. The diagnosis on this case was made in retrospect one year later. Cottam[4] in 1917 reported a death following cholecystostomy. There was a duration of three days between the onset of symptons and surgery in this case.

CASE REPORT

The patient, a 67-year-old white man, was admitted on March 22, 1955, with onset of symptoms on March 20. He had a history of right lower quadrant pain localizing in the right upper quadrant. The pain was constant, increasing in severity, and not associated with any colicky episodes.

Physical examination revealed a mildly toxic patient with temperature 100.2° F., right upper quadrant pain, tenderness, and rigidity. There was minimal edema of the skin in the right upper quadrant.

The laboratory report revealed packed cell volume 50, white blood cells, 14,200 with 84 per cent polys; urine: albumin 2 plus, sugar 2 plus, micro. negative.

Chest roentgenogram showed minimal atelectasis of the left lower lobe. Erect and flat plates of the abdomen (Fig. 1) demonstrated multiple distended loops of small and large bowel with a gas-filled gall bladder containing a fluid level. This latter finding was not appreciated until surgery.

The patient was operated upon a few hours after admission with a preoperative diagnosis of acute cholecystitis. Exploration revealed an acute gangrenous cholecystitis. An 18 gauge needle connected to a suction was inserted into the fundus of the gall bladder and approximately 100 c.c. of foul-smelling gas was obtained. No fistula between the gastrointestinal tract and the gall bladder could be demonstrated. The x-ray findings at this time were reviewed, establishing the diagnosis of acute pneumocholecystitis. Cholecystectomy was performed and drains inserted into Morrison's pouch. Closure was routine and the patient returned to the ward in good condition.

Postoperative course was uneventful. The patient became afebrile on the third postoperative day and was discharged on the eighth postoperative day. One gram of tetracycline was given daily for five days.

Histopathology revealed a gangrenous cholecystitis and review of the slides could not demonstrate evidence of emphysema within the wall of the gall bladder. Culture of the gall bladder under anaerobic conditions produced *Clostridium perfringens.*

SUMMARY

1. Thirty-eight cases of acute pneumocholecystitis including a report of one of our own have been reviewed from the literature and reported.

2. X-ray examination of the abdomen is necessary to establish the diagnosis preoperatively.

3. Cholecystectomy early in the disease process is the treatment of choice.

4. Perforation is a common complication when treatment is delayed.

5. A high mortality is associated with delayed treatment.

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AN EFFICIENT STOOL COLLECTOR

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(From the Department of Surgery, State University of New York, College of Medicine at New York City)

IN THE differential diagnosis of obstructive jaundice, analysis of the urine and stool for urobilinogen has often been found most helpful. The Watson test[3-5] is now used both at the University of Minnesota Hospitals and at Kings County Hospital in studying jaundiced patients suspected of having extrahepatic biliary obstruction.[1, 2]

Watson[3] suggests that the stools for this test be collected for two forty-eight hour periods in waxed, cardboard containers, which should be kept in a cool, dark place during the period of collection. The apparatus described is an attempt to facilitate such a collection with a minimum of nursing and technical aid.

DESCRIPTION OF APPARATUS

The collector has been constructed in two units. The first consists of a bedpan with a large hole in the bottom, into which a steel cannister with an insulated cover has been fitted. A one-quart waxed cardboard container fits snugly into this cannister, directly collecting the specimen.

The collecting cannister is inserted into a bucket within which a framework of screening has been built. When the apparatus is to be used, the space between the collecting cannister and the outer bucket is filled with dry ice. This is then covered with some insulating material such as cotton or large dressing pads. The entire apparatus has been placed on a movable stand.

DISCUSSION

The significance of the Watson stool urobilinogen test lies in its accuracy in differentiating a biliary calculus from neoplastic biliary obstruction in the patient with obstructive jaundice. Watson[4] has shown that in obstruction due to neoplasm, the fecal urobilinogen is almost never more than 5 mg. per day. If jaundice is caused by a stone or diffuse liver disease, there is rarely less than 10 mg. of urobilinogen per day in the feces. The fecal urobilinogen is normally from 40 to 280 mg. per day, and usually between 100 and 200 mg. per day.[5]

At the University of Minnesota Hospitals, the test is claimed to have an accuracy of over 90 per cent. Of the nine patients studied at Kings County Hospital in the past year, six were found to have daily fecal urobilinogen outputs of less than 5 mg. At exploration each of these six cases proved to have neoplastic biliary obstruction. Of the three patients with daily fecal urobilinogen outputs greater than 5 mg., one was found to have chronic cholecystitis with

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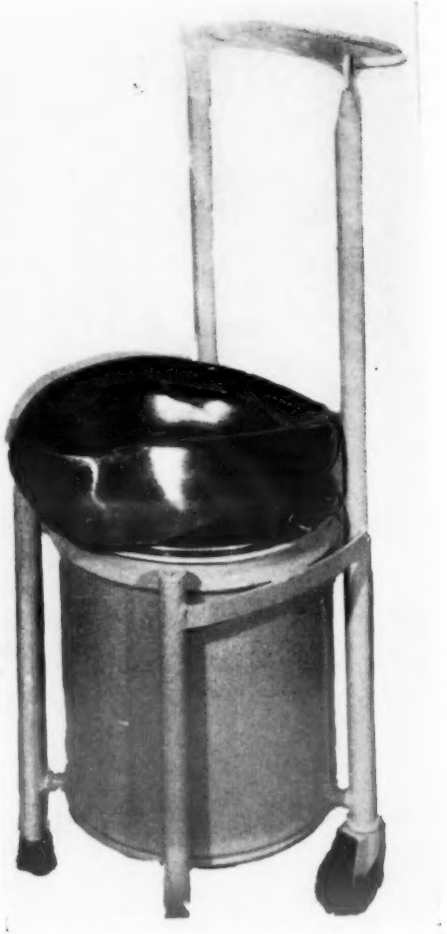

Fig. 1.

Fig. 2.

Fig. 1.—The fully assembled stool collector.
Fig. 2.—The collector is separated into its components for autoclaving. Dry ice is placed between the screening and the outer walls of the container.

cholelithiasis, one improved and was discharged later with a diagnosis of hepatitis, and the third expired before exploration could be performed. Consent for autopsy could not be obtained.

One dramatic instance of the accuracy of the test was recently encountered. A 63-year-old Negro man was admitted to Kings County Hospital with a one-month history of right upper quadrant abdominal pain which was accompanied by pruritis and jaundice for the ten days prior to admission. Examination

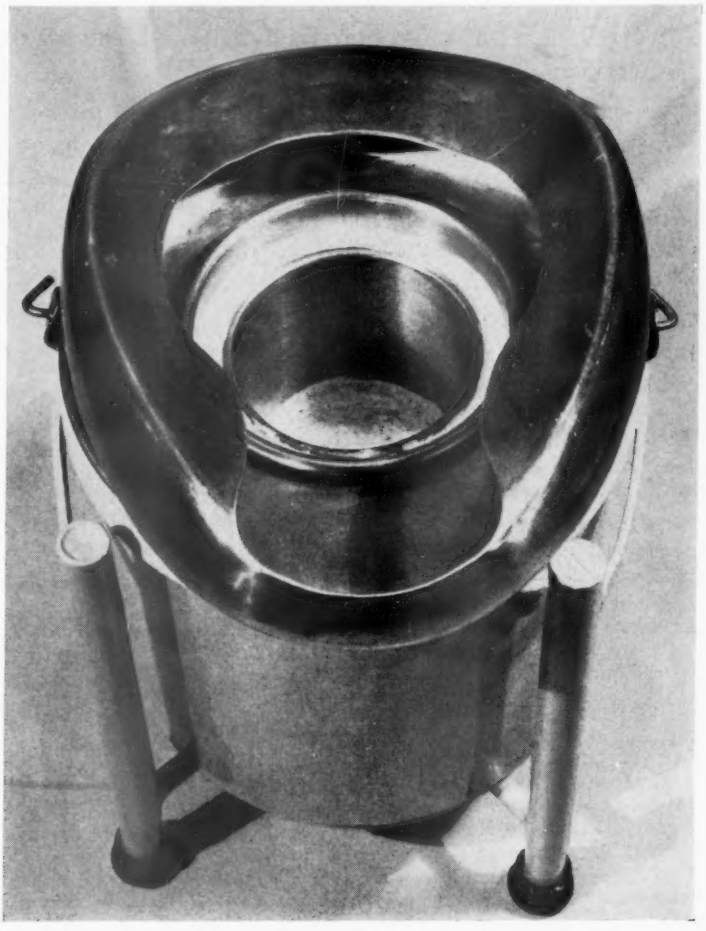

Fig. 3.—A waxed cardboard container fits snugly into the inner cannister and the stools are collected directly therein.

revealed an enlarged liver and slight tenderness in the right upper quadrant. Blood and urine studies indicated the obstructive nature of the jaundice. The stool urobilinogen was 1.3 mg. a day. A working diagnosis of neoplastic biliary obstruction was made.

At exploration, the gall bladder was found to contain many calculi, and a stone was found in the common bile duct, with a stricture just proximal to it. The process was considered benign and a cholecystectomy and resection of the

strictured area of common duct were performed. Microscopic study, however, revealed an adenocarcinoma involving the gall bladder, common and cystic ducts, consistent with the preoperative Watson test report.

According to Watson,[6] polypoid carcinomas of the common bile duct and carcinomas of the ampulla cause incomplete obstruction in some cases. Complete obstruction is the general rule with carcinomas of the pancreas and scirrhous carcinomas of the bile ducts. Watson states his early figure of 90 per cent complete obstruction in biliary tract neoplasms was based on a series containing relatively few cases of carcinoma of the ampulla and polypoid carcinomas of the common duct. If more of these were included, he states, the per cent of incomplete obstruction would be greater.

The stool collector described has been found to be an odorless, simple method of directly collecting the entire four-day stool output of the patient. The stool is weighed in the same container in which it has been collected, the weight of the container alone having been previously determined. The machine itself need be looked at only once a day after it has been placed at the patient's bedside and the necessary instructions given to the patient. Each morning, the outer container is filled with dry ice and at the end of forty-eight hours the first waxed container is replaced. The entire collecting portion of the apparatus is of stainless steel and may be autoclaved.

SUMMARY

A simple, efficient stool collector is described. It may be used whenever stools must be collected for several days, and finds particular use in connection with the Watson Stool urobilinogen test.

The author wishes to thank Drs. Clarence Dennis and Irving Enquist for their interest and thoughtful advice.

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Case Reports

ACUTE ARTERIAL OCCLUSION: AN UNUSUAL CAUSE

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(From Vancouver General Hospital)

THIS is the case report of a rather obese 61-year-old white woman who was admitted to the hospital five hours after she had fallen and sustained a fracture of the surgical neck of the right humerus. There were marked swelling and ecchymosis in the region of the right shoulder, a definite coldness of the right hand and forearm, an absence of the radial and brachial pulses, and a cyanotic pallor of the hand and forearm. Because of the patient's alcoholic state it was impossible to determine whether or not she had anesthesia and paralysis.

Roentgenograms revealed a fracture of the surgical neck of the right humerus with marked medial displacement of the distal fragment. Under right brachial plexus nerve block the fracture was reduced, but this failed to relieve the signs of acute arterial occlusion. At this stage I was asked to see the patient and I diagnosed a torn axillary artery, recommending exploration of this vessel with the hope of restoring the arterial blood flow.

Fig. 1.

This operation was performed seven hours after the accident. A delta pectoral incision was used; the deltoid muscle was retracted laterally and the insertion of the pectoralis major muscle divided. A moderate-sized hematoma was found to be due to a torn vein. The axillary artery, its branches, and the exposed part of the brachial artery were intact. In the upper part of the brachial artery there was a purplish blue discoloration about three-fourths inch long. This portion of the artery was not compressible but was firm, with a pulsation above and none below. This was diagnosed as a thrombosis. Blalock clamps were applied to the artery above and below the lesion and a longitudinal incision made over the discolored area; the edges were retracted and the thrombus removed. Attached to the lower end of the thrombus was a completely free cast of the inner layers of the artery. This cast measured 1 cm. in length (Fig. 1). The opening in the

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artery was closed with continuous No. 5-0 black silk. Since the operation the patient has had an excellent radial pulse and a normally functioning hand with normal sensations. This report was written 42 days postoperatively.

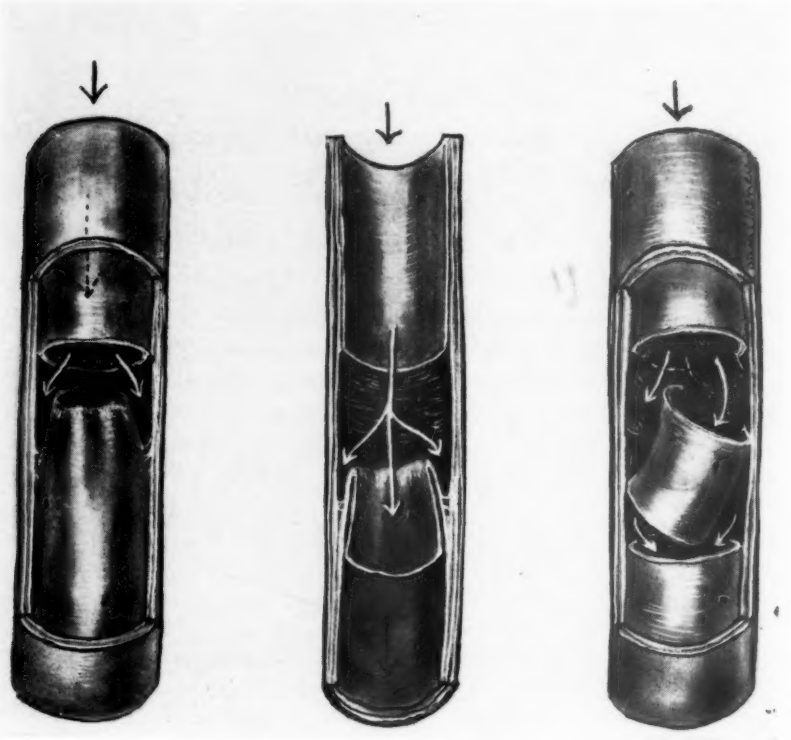

Fig. 2.

SUMMARY

In attempting to explain this unusual cause of arterial occlusion, it was felt that the lower fragment of the fractured humerus had acutely angulated the artery, and that the inner layers had been fractured. The pathologic report stated that the specimen consisted of intima, some of the media, and some elastic tissue, and that the intima was on the outside of the specimen; therefore, we must conclude that the inner layers were partially separated by the injury and the pressure of the blood turned the specimen inside out and it then broke off at a lower level. Fig. 2 illustrates my interpretation of the injury to the artery.

SURGICAL SEPARATION OF SIAMESE TWINS: CASE REPORT

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THE rarity of Siamese twins, and the fact that surgical separation is seldom feasible, justifies reporting the survival of one twin following surgery.

CASE REPORT

Siamese twins were born at 8 P.M. on May 23, 1955, to a 20-year-old Negro woman whose one previous pregnancy resulted in delivery of a normal infant. The twins were sent to the New Orleans Charity Hospital because one infant was in extremely poor condition.

Physical examination on admission revealed female Siamese twins joined face-to-face at the lower abdomen and pelvis, with a combined weight of 8 pounds (Fig. 1). The larger twin (No. 1) seemed relatively normal and had a good color, a strong cry, and normal breath sounds. The only visible anomaly of this infant consisted of attachment of the thighs at right angles to the trunk. On the left side of the abdomen was a normal umbilicus and umbilical cord; on the right side was an area resembling a healed umbilicus. The smaller twin (No. 2) was deeply cyanotic and did not respond to painful stimuli. She was grossly malformed, with one misshapen eye, micrognathia, severe scoliosis, and club feet. There were no breath sounds audible over the chest. The cyanosis ended abruptly at the waist, and the lower extremities were of normal color, indicating direct continuity of circulation between the two infants.

The twins were joined primarily at the pelvis, which formed one bony ring for the two children. This may perhaps be best understood by visualizing the pelvis as a complete circle of 360 degrees, with the sacrum of twin No. 1 at 0 degrees and that of twin No. 2 at 180 degrees. There was one symphysis at 90 degrees and another at 270 degrees. The external and internal genitalia were in proper relationship to the symphyses, disregarding the fact that each baby contributed one pubic ramus to each symphysis. Examination of the perineum revealed two sets of external genitalia aligned at right angles to the vertical axis of the conjoined twins (Fig. 4, *B*). On one side the vagina was bipartite. On the side of the perineum near the larger twin was a midline fissure with no apparent internal connection; on the side near the smaller infant was a small midline orifice without sphincter.

Because of the precarious condition of the smaller twin it was elected to attempt surgical separation of the babies with a minimum of preoperative investigation. Autopsy findings later confirmed the fact that this parasitic twin not only was incapable of independent existence but would inevitably have succumbed and caused the death of the viable child.

Anteroposterior and lateral roentgenograms yielded very little additional information (Figs. 2 and 3). The heart shadow of the larger child could not be identified, but the heart tones were normal to auscultation. The chest of the smaller infant apparently contained no air. Radiopaque material was injected into each orifice in the perineum. A catheter inserted into the single vagina apparently entered the urethra and filled a normal bladder. Contrast material injected into each half of the double vagina outlined the vaginas and escaped into the perineum. Injection through the midline opening filled a

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hollow viscus which was thought to be the second bladder. (The error became apparent when meconium later escaped from this orifice.) Injection of Fluorescein* into the one umbilical vein revealed a normal circulation time for the larger twin with belated appearance of fluorescence in the smaller one. This was interpreted as indicating that the umbilical vessels belonged primarily to the larger twin.

The twins were taken to the operating room at the age of 18 hours, and twin No. 1, the larger and more normal child, was placed supine on the table. The head and shoulders of twin No. 2, the deformed infant, were held upright. Twin No. 1 was given a general anesthetic after a polyethylene tube was inserted into the right antecubital vein. Extensive skin preparation included the legs, abdomen, chest, and back of each infant as well as the common perineum. Sterile sheets were placed under the conjoined bodies and over an ether screen to exclude the head, shoulders, and arms of twin No. 1 from the operating field. Sterile stockinette was used to cover the head, shoulders, and arms of twin No. 2.

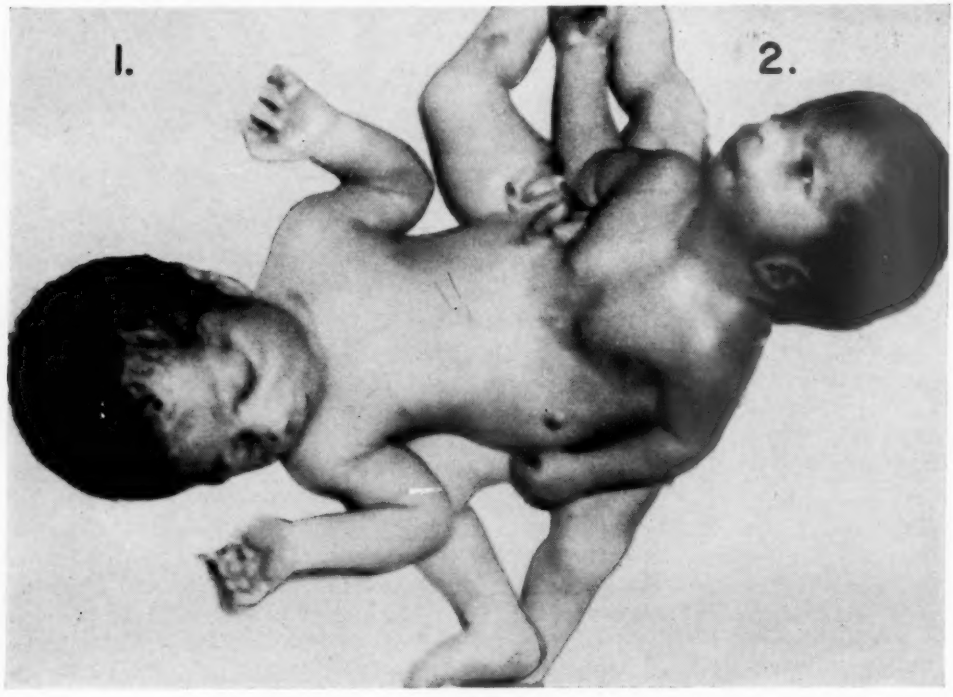

Fig. 1.—The larger twin (No. 1) was relatively normal. The smaller child (No. 2) was moribund.

A curved incision was made over the costal margin of twin No. 2 (Fig. 4). After dividing the muscle, the pericardium and left pleural space of twin No. 2 were opened. The heart was large and dilated and the lung was not palpable. The common peritoneum was opened just below the costal margin of twin No. 2, thus preserving peritoneum, muscle, and skin for twin No. 1. There was only one umbilical vein, which ran from the single umbilicus to the liver of twin No. 1. The two livers were connected in the anterior midline over a 1 by 3 cm. area. Mattress sutures were placed and tied on either side of the line of junction and the liver tissue divided between the sutures.

The small intestine of twin No. 1 contained swallowed air and was grossly normal, while that of twin No. 2 was small and collapsed. There was only one terminal ileum and colon, with complete absence of fixation of the right colon. A moderate dilatation of the ileum and a Meckel's diverticulum occurred where the two intestinal tracts joined. The

*C. F. Kirk Company.

Fig. 2.—Preoperative roentgenograms demonstrated the small head and vertebral deformities of twin No. 2. The swallowed air is in the intestinal tract of twin No. 1.

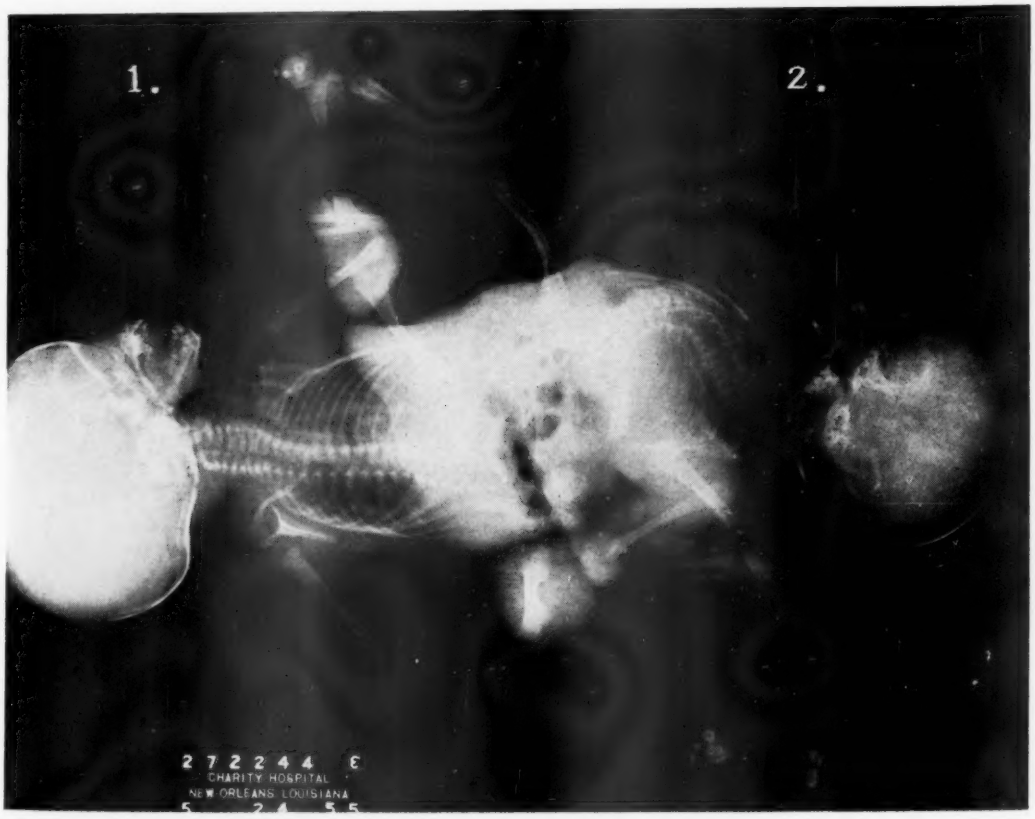

Fig. 3.—The chest of twin No. 2 contained no air. The heart shadow of twin No. 1 was not visible.

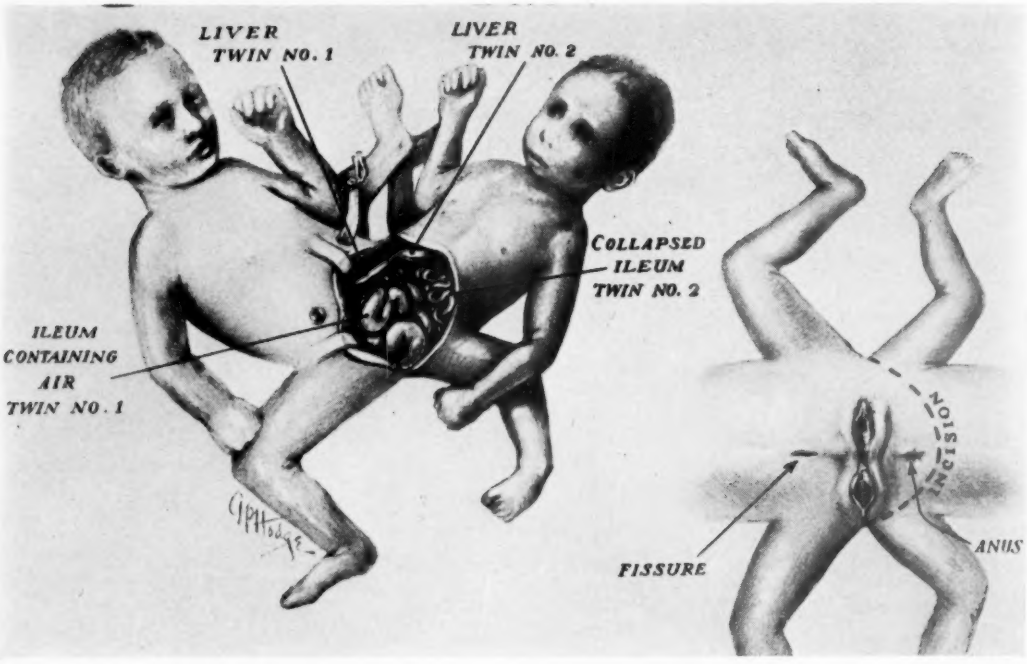

Fig. 4.—The incision was started over the costal margin of the nonviable twin (No. 2), continued laterally and inferiorly to separate the legs, and was completed by saving the entire perineum for the viable twin (No. 1). The intestinal tract of twin No. 1 seemed normal; that of twin No. 2 was collapsed. A fissure marked the line of junction of the conjoined livers. The insert shows the alignment of the external genitalia, with the bipartite vagina on one side.

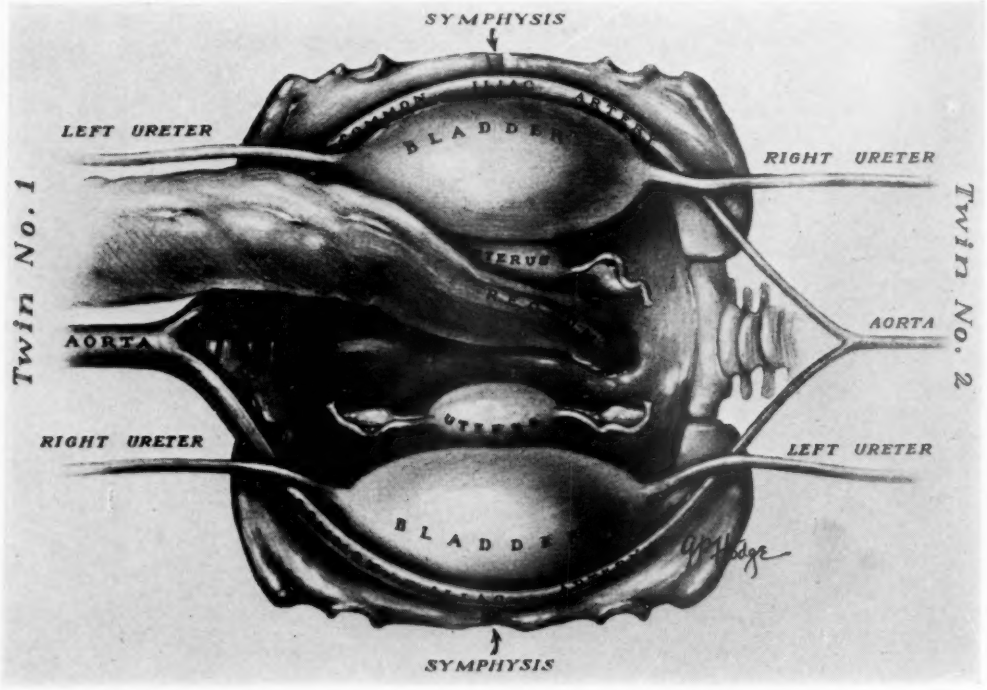

Fig. 5.—The single rectum emptied through the single anus on the twin No. 2 side of the perineum. The bladders and uteri were shared by both infants. The iliac arteries continued from twin No. 1 to twin No. 2 and joined again to form a hypoplastic aorta for twin No. 2. The origins of the femoral and hypogastic arteries were not identified. The pelves were united into one bony ring for the two children, each twin contributing a pubic ramus to each symphysis.

Fig. 6.—Two weeks postoperatively the incision was well healed. The normal umbilicus is on the left. The abnormal attachment of the legs to the trunk prevents drawing the legs into a normal position.

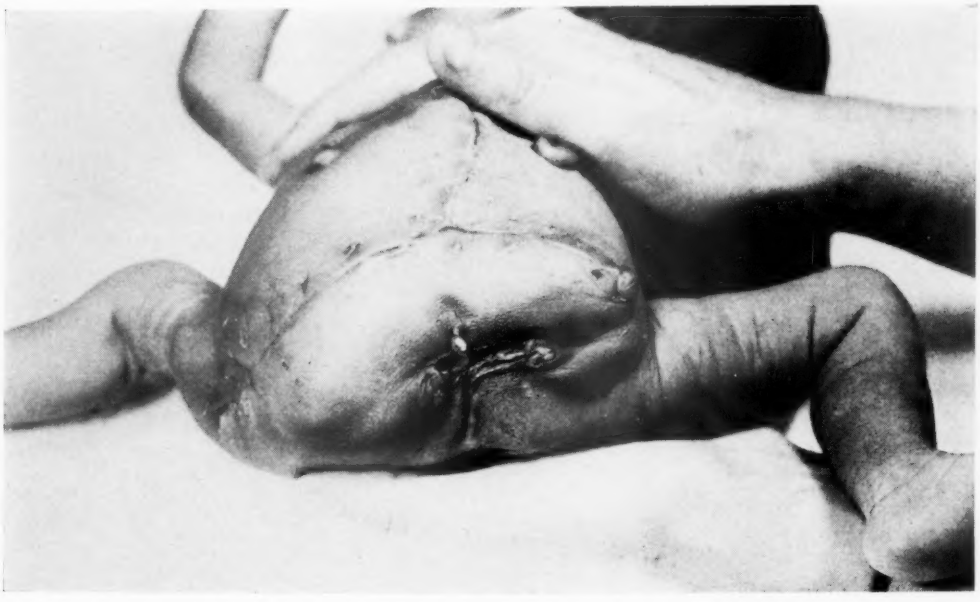

Fig. 7.—The surviving twin possesses two sets of external genitalia, with three vaginas. (The double vagina on the left is not visible in this photograph.) The anus is anterior to the genitalia and is indicated by the small speck of pale feces. The posterior midline fissure has almost healed.

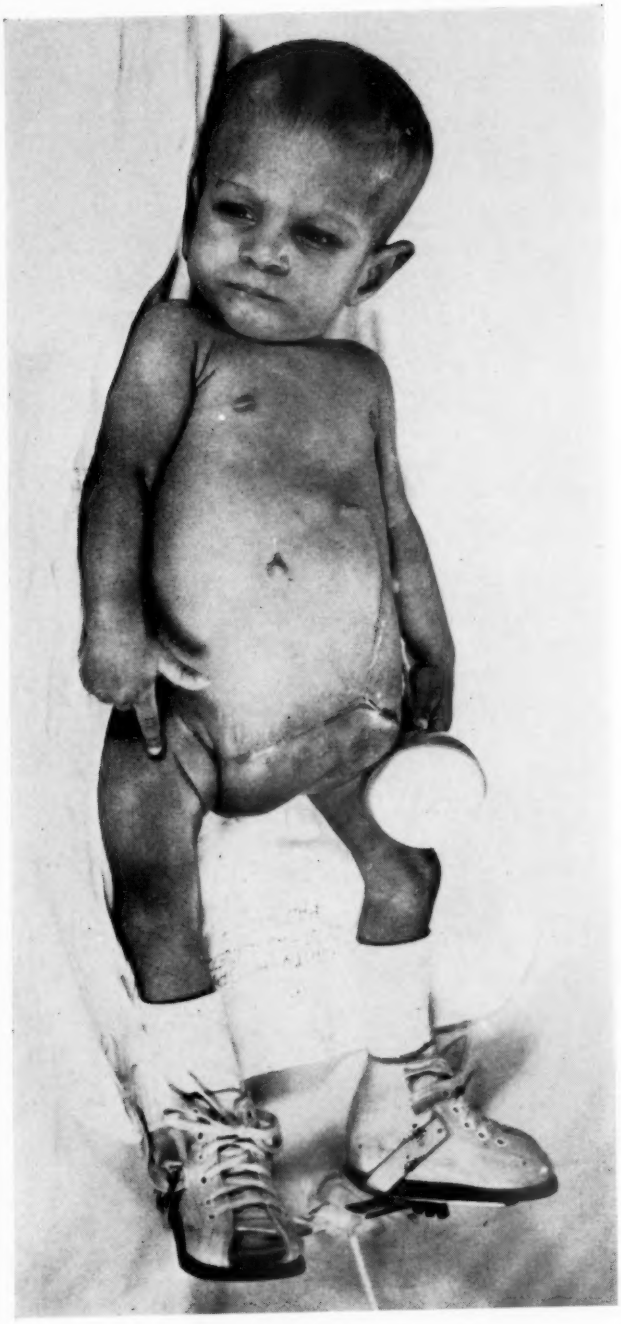

Fig. 8.

colon emptied through the single anus, which was on the twin No. 2 side of the perineum. The ileum of twin No. 2 was transected where it joined the common terminal ileum and the opening on the twin No. 1 side was closed in layers.

Two urinary bladders and two uteri were shared by both infants; that is, one ureter of each child drained into each bladder, and one tube of each uterus extended into the pelvis of each child (Fig. 5). The ureters of twin No. 2 were divided at the ureterovesical junction, saving both bladders for twin No. 1. The iliac vessels, which continued across the pelvis from twin No. 1 to twin No. 2, were ligated and divided. The pelves, which formed one complete ring for the two infants, were separated at the pubic symphyses.

The skin incision was continued laterally and inferiorly on each side to separate the legs of twin No. 2 from those of twin No. 1. The two lateral ends of the incision were then continued posteriorly and medially (Fig. 4, *B*), saving the entire pelvic peritoneum and perineum for twin No. 1 and completing the separation of the twins.

The viable twin thus possessed a complete gastrointestinal tract, with a Meckel's diverticulum and a malrotation; two kidneys normal to palpation, each draining into a separate bladder; two uteri with four tubes and four ovaries; and three vaginas, the genitalia on the left having a double vagina.

Vertical midline closure of the abdominal wall and transverse closure of the perineum to the lower abdomen was easily accomplished (Figs. 6 and 7). Because of the malrotation, the entire colon was placed on the left side of the abdomen and the small bowel on the right. The peritoneum was adequate and the fascial closure satisfactory throughout. The surviving twin (No. 1) tolerated the procedure surprisingly well. A transfusion of 250 c.c. whole blood was completed before the child left the table to return to the premature nursery.

Autopsy on the nonviable twin revealed the following additional anomalies: dilated heart with a single atrium and a single ventricle, hypoplastic lung on the left containing no air, complete absence of the right lung with obliteration of the right pleural space, and absence of the spleen.

The surviving twin weighed 5 pounds, 4 ounces on the first postoperative day. Oral fluids were well tolerated on the second day, so parenteral fluids were discontinued. Minimal difficulty in passing stools was relieved by anal dilatations. Even though neither urethra was clearly identified, a normal stream of urine was seen coming from each set of external genitalia.

A few days postoperatively a heart murmur was heard. Whether this indicates a congenital heart disease remains to be seen. At the end of two weeks the infant regained her birth weight and seemed to be in excellent condition.

Orthopedic consultants are studying the problem of future ambulation. The pelvis, instead of forming a closed ring, is an open semicircle, with the divided ends of the symphysis widely separated and extending directly inferiorly. In addition, the acetabulum on each side is displaced superiorly and posteriorly. Traction on the legs may make possible some sort of gait.

SUMMARY

The pathologic anatomy of female Siamese twins is described and the operative procedure of separation outlined. The viable twin survived the surgery and is in good condition at the time of this report.

I wish to express my appreciation to Dr. W. T. Newsom, Director of the Premature Center of the New Orleans Charity Hospital for his assistance in the preoperative studies and also for the preoperative photograph of the twins.

ADDENDUM

At the age of eight months the surviving twin is in good health (Fig. 8). Mental development is normal, and the precordial murmur has disappeared. The legs were brought into a more normal position with skin traction and held there with a Dennis-Brown bar.

ADENOCARCINOMA OF INFRAHYOID THYROID TISSUE

Case Report

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(From the Surgical Service, Dayton State and Receiving Hospital)

IN VIEW of the embryologic development of the thyroid gland, it is surprising that ectopic thyroid tissue in the thyroglossal tract is so infrequent.

The anterior two-thirds of the body of the tongue originates from the paired lateral swellings of the first branchial arches and from the tuberculum impar, a rounded elevation of the entoderm between the ventral ends of the first branchial arches. The posterior part of the tongue arises primarily from the ventral ends of the second pair of branchial arches, there being contributions from the third and possibly also the fourth arch. The two parts of the developing tongue are separated by a V-shaped groove, the terminal sulcus. The thyroid anlage begins as a pouchlike depression which develops at the apex of the terminal sulcus, this point remaining as the permanent pit termed the foramen cecum. The thyroid anlage thickens to form a solid mass growing down through tissue which later becomes the hyoid bone. With the downward growth, there is a dragging down of the epithelial elements of the pharynx, and the lining of the thyroglossal duct may be squamous or ciliated columnar epithelium. The hyoid bone presses against the tract, dividing it into two portions, and as it grows the hyoid further divides the tract into an upper and lower anterior and a lower posterior portion. With further fetal development, the entire tract usually disappears.[1, 2]

Clinically, cysts may be found anywhere along the thyroglossal tract,[1, 2] and occasionally thyroid tissue is found in the wall of the cyst.[2, 8] A few cases have been reported of thyroid tissue in the wall of thyroglossal cysts.[2, 9, 12]

Normal or neoplastic thyroid tissue has been observed several times at the base of the tongue (lingual thyroid).[2, 6, 7] In many of these cases, no thyroid gland is present in the normal location.[4, 6, 11]

However, we have been unable to find a published report of a primary infrahyoid thyroid carcinoma unassociated with a prominent thyroglossal duct or cyst. A recent case in which a solid adenocarcinoma was found in the midline submental area is therefore reported in detail at this time.

CASE REPORT

J. R., a 66-year-old white man, was admitted to the Dayton State Hospital on Jan. 27, 1954, with a diagnosis of psychosis with cerebral arteriosclerosis. At the time of admission, a submental mass was seen by the examining physician, and was visible on the admission

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photograph (Fig. 1). It was thought to be a lipoma and no further investigation was made until the routine admission dental examination, at which time the patient was referred from the dental to the surgical service (Feb. 9, 1954) for evaluation of the mass.

The patient was asymptomatic and stated that the "swelling" had been present for several years and "gave no trouble." As the reliability of the patient's statements was doubtful, his family was also questioned. They had first noted it about three years previously while visiting the patient in a nursing home. One of the brothers thought it grew for the first six months and then remained stationary; another thought it stationary until the past six months, when it enlarged. No swallowing difficulty or other symptoms had been observed.

One informant stated that the patient had had a "goiter about the size of a hen's egg on the side of the neck" in about 1918. He recalled that it was definitely "much lower in the neck" than the present mass, and pointed to the normal thyroid area as its site. The "goiter" was said to be particularly noticeable when the patient swallowed. At that time, according to the relative, the patient mentioned several times that it was rather difficult for him to swallow, it being very unusual for him to complain of any discomfort. He consulted a physician and some type of nonsurgical treatment was given, after which the "goiter" disappeared and did not recur.

Fig. 1.—Admission photograph, showing abnormal submental contour.

There were no other symptoms until about sixteen years later when the patient developed a sore throat lasting for two to six weeks at which time "ulcers with pus" appeared in the throat, responding to treatment with local medication. There was no history of previous or subsequent metabolic disturbance.

Physical examination revealed a robust-looking white man with a right inguinal hernia and hydrocele and no further abnormality of note other than a large, smooth, firm, round mass about 5.5 cm. in diameter in the midline submental area. The mass moved very slightly on swallowing, but the impression was gained that its large size and position prevented motion. There were no other palpable cervical masses, and no adenopathy was noted. The thyroid gland was barely palpable and seemed smooth and symmetrical.

Because of its location and consistency it was thought that the mass was a tense thyroglossal cyst.

Barium fluoroscopic studies of the neck and x-ray examinations of the neck and chest were made. These revealed no obstruction to the passage of barium and no evidence of fistulas or diverticula. The mass lay anterior to the trachea and no compression of the trachea or esophagus was noted.

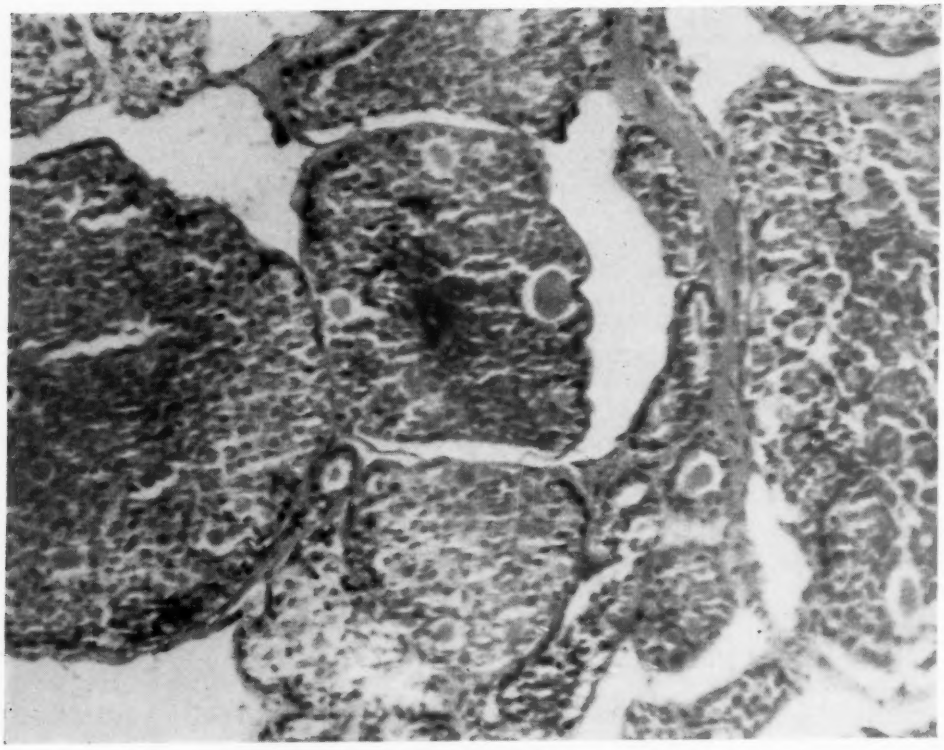

Fig. 2.—Shows carcinoma with papillary and follicular arrangement with some follicles showing colloid (×200; reproduced same size).

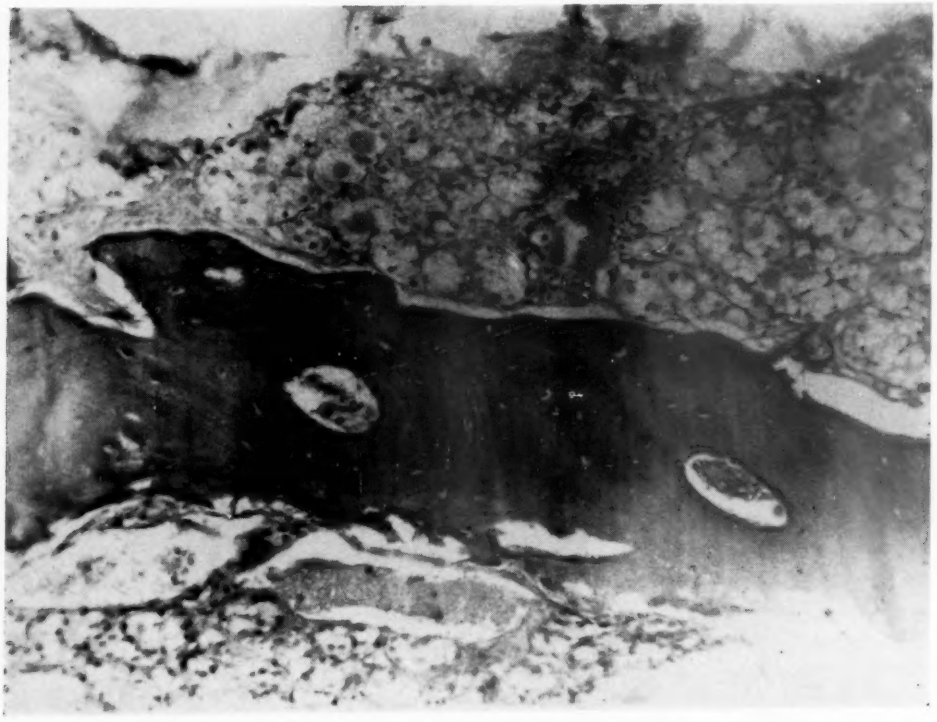

Fig. 3.—Portion of hyoid bone showing slight erosion of periosteum on inferior surface of tumor. Salivary gland tissue is seen on the superior surface.

Serologic tests for syphilis, complete blood count, and urinalysis were within normal limits. Basal metabolic rate was -23 per cent.

On March 10, using endotracheal anesthesia, a horizontal incision was made over the mass which was found to lie in the midline beneath the cervical fascia. The well-encapsulated mass was immediately anterior to the hyoid bone, covering it almost entirely and closely attached to the central portion of the bone, with apparent erosion of most of the hyoid extending to both cornus. The hyoid appeared to be displaced slightly upward by the mass. Inferiorly there was no evidence of a pyramidal lobe connection or other tract leading toward the thyroid. The mass, which grossly resembled a normal thyroid lobe in size and appearance, showed no attachment to surrounding structures other than the hyoid. The central portion of the hyoid was completely excised, being removed with the tumor. Only a small part of each lateral portion of the hyoid remained because of the attempt to remove a little normal bone on either side of the area of erosion. A finger placed intraorally detected no additional masses, and no tract or duct was found extending from the posterior surface of the hyoid or tumor despite thorough dissection of this area. A thin but continuous layer of grossly normal tissue separated the intraorally placed finger from the area of cervical exploration. No attempt was made to reapproximate the hyoid bone, as the remaining portions were so widely separated that it was felt undue tension would result. The sternohyoid tendons were approximated, a Penrose drain placed, and the wound closed with clips. The postoperative course was entirely uncomplicated, the patient being able to eat without difficulty the morning following surgery. The wound healed uneventfully.

The pathologic report (microscopic) was as follows: Microscopic examination (Fig. 2) showed cells of thyroid type in both papillary and follicular arrangement. Some contained eosin-staining colloidlike material. In some areas the cytoplasm was acidophilic and finely granular, suggesting, somewhat, Hürthle cells. There was a thin layer of fibrous tissue surrounding each follicle. In many places the tumor growth was in a solid arrangement. There was a sprinkling of mitoses throughout. Blood vessel invasion was not observed in three sections examined. The tumor seemed fairly well encapsulated. Section through hyoid bone showed glandular tissue resembling salivary type on the superior surface. The inferior surface showed slight erosion of the periosteum and tumor follicles in close proximation (Fig. 3). A diagnosis of carcinoma of thyroid tissue was made.

On March 25 (20 days after the operation), radioactive iodine studies were made to determine whether an active thyroid gland was present in the normal location and whether active thyroid tissue was present elsewhere in the neck. The patient was given 10.02 μc of I^{131} as a tracer dose and twenty-four hours later an uptake of 33.25 per cent was determined over the anterior thyroid area. Further survey of the area with the scintillation counter revealed no significant uptake in other sections of the neck from the level of the base of the tongue to the sternum.*

On April 20, the basal metabolic rate was +10. The patient remained completely asymptomatic, being examined at regular intervals, and no abnormality was noted until September 22, when chest roentgenograms showed apparent destruction of the right fifth rib posteriorly and a mass extending from approximately the second to the fifth rib level. There was no demonstrable chest-wall tenderness or any palpable mass in the region of the chest, neck, or elsewhere at that time. Review of the original tumor sections at this time showed three areas suggestive of blood vessel invasion.

He was again referred to the Isotope Laboratory, and 9.0 μc of I^{131} administered on October 12, revealed a 32.5 per cent uptake. Contact counts showed a noticeable increase in I^{131} uptake over the lower mid-neck region. There was no evidence of selective uptake over the chest anteriorly and posteriorly, nor in the lymph nodes in the lateral aspects of the neck, or in the region of the spinal column.

*These studies were made by Dr. R. E. Zipf, Director of Isotope Laboratory, Miami Valley Hospital, Dayton, Ohio.

The patient was referred to the Thoracic Surgery Service of the Ohio State University Hospital where, on Nov. 12, 1954, block resection of the right chest wall, including the fourth, fifth, and sixth ribs was carried out, with pulmonary biopsy. Diagnosis was thyroid carcinoma, similar to the original tumor, metastatic to the right fifth rib.

Because the one metastasis did not take up I^{131}, and because of the remote possibility that the original submental lesion was of metastatic origin, on Feb. 3, 1955, a total thyroidectomy was performed, with uncomplicated postoperative recovery. At the time of thyroidectomy, the isthmus was found to be quite small, with no evidence of a pyramidal lobe or of a tract or duct extending toward the hyoid. A few small colloid nodules were present, but thorough sectioning of the thyroid revealed no evidence of malignancy.

Subsequently, the large inguinal hernia and hydrocele were repaired, and the patient remained under observation from the metabolic standpoint. Laboratory studies at present indicate mild hypothyroidism and, following repeat skeletal x-ray and I^{131} surveys, further treatment will be planned.

DISCUSSION

Since it appears that up to the present time no other case of primary subhyoid thyroid carcinoma unassociated with a thyroglossal duct or cyst has been described, careful studies were made of the differential diagnosis in this case.

A lingual thyroid associated with an adenoma which presented in the submaxillary triangle of the neck was described by Zaslow, Sklaroff, and Kornfield in 1954.[13] The adenomatous portion was apparently somewhat similar in location to the malignant tumor found in the present case, except that it was located in the right side of the neck and attached to the right cornu of the hyoid bone, whereas, in our patient, the tumor was midline in position. In their case, the lingual thyroid discovered after removal of the adenoma represented all of the thyroid tissue present. In the present case, however, palpation and I^{131} studies revealed the presence of normally functioning thyroid in the normal location, and no lingual component.

As several cases have been reported of carcinoma arising in a thyroglossal cyst,[8] the specimen was studied grossly and microscopically for evidence of a cyst. Since grossly no cyst was seen, the possibility was considered that the tumor originated from thyroid tissue in the wall of a thyroglossal cyst and that the expanding tumor growth completely filled the cyst obliterating evidence of a cyst wall (although in all cases previously reported it was possible to identify the cyst wall). In a study of 41 cases of thyroglossal cysts and fistulas, Webb[12] found that the most common lining was a mixture of simple cuboidal with columnar epithelium. Well-differentiated pseudostratified ciliated columnar epithelium was seen in some, and well-developed goblet cells were noted. The third common type of lining seen by Webb was stratified squamous epithelium. Occasionally parts of the wall were lined by a single layer of flattened epithelium. He also observed some instances of salivary glandular tissue, mucous glands, sebaceous glands, and lymphoid tissue in association with cyst walls. In our specimen, careful examination of the tumor surface was made in an effort to identify any such cell type consistent with a thyroglossal cyst wall. Although a few nests of salivary type glandular tissue were seen on the upper border of the hyoid bone (Fig. 3), the tumor mass, which was below the hyoid, showed only a rather thick fibrous capsule (Fig. 4).

Association of a midline cervical tumor with a thyroglossal duct was reported by O'Kane and Straus[9] in 1953. Their patient had a painless mass "between the hyoid bone and the thyroid cartilage." This nodule was apparently similar in location to that of the present case, being ". . . just beneath the strap muscles and just inferior to the hyoid bone." The microscopic diagnosis in their case was "papillary adenocarcinoma similar to such lesions of the thyroid gland." In their patient, a stalk from the inferior pole of the mass led to a pyramidal thyroid lobe which continued to the isthmus of the gland, and, superiorly, "a definite thyroglossal tract coursed from the level of the tumor through the hyoid bone to the foramen cecum." In contrast, the pretracheal area in our patient was completely clear, there being no pyramidal lobe

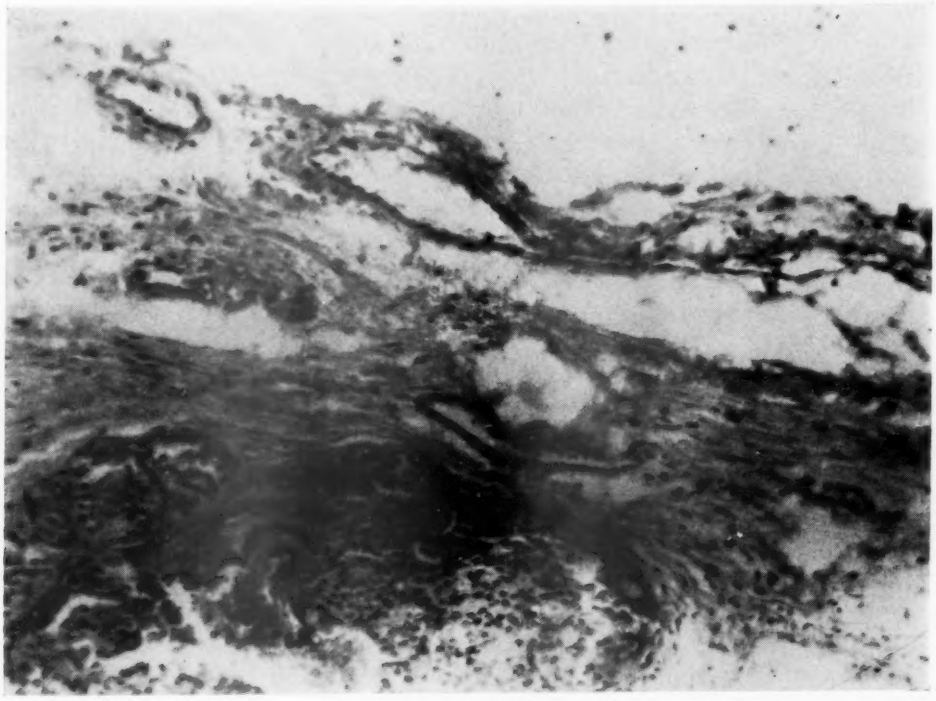

Fig. 4.—Edge of tumor showing thick fibrous capsule. The tumor tissue shown is in follicular arrangement (×200; reproduced same size).

and no evidence of any duct extending either caudad or cephalad from the tumor. Because of the possibility that a tract too small to be seen grossly existed, sections were taken from the part of the tumor that had been adherent to the central portion of the hyoid, but nothing resembling such a structure could be identified microscopically.

The possibility was also considered that this tumor was a type of "aberrant thyroid," probably representing a lymph node metastasis from a carcinoma primary in the thyroid isthmus. In discussing metastasis from adenocarcinoma of the thyroid, MacFee[7] stated (1953) that his findings confirmed Sloan's observations that it is uncommon for the disease to extend to the submental and submaxillary areas.[10] The Delphian node described by Cope and associates[3] is

situated far caudad to the submental area, being located in the midline of the neck "just above the upper border of the thyroid isthmus and in front of the middle cricothyroid ligament." The mid-anterior surface of the hyoid bone, where the tumor was found in this case, is not described as being in the course of lymphatic drainage from the thyroid. A careful microscopic examination of the specimen showed no evidence of the presence of lymph node structure. Also, multiple sections of the thyroid gland at subsequent total thyroidectomy revealed no evidence of neoplasm in the gland.

SUMMARY

A case is reported in which a primary papillary adenocarcinoma of thyroid tissue was found in the submental area, closely adherent to the central portion of the hyoid bone. No association with a thyroglossal duct or cyst could be demonstrated. There was no lingual thyroid and the thyroid gland itself was essentially normal. No report of an exactly similar case could be found. Despite the long duration and asymptomatic character of the lesion, thoracic metastasis was noted a few months after its diagnosis. This case further emphasizes that definite diagnosis of masses in the neck should be made as early as possible to ensure maximum efficacy of treatment.

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CERVICAL ESOPHAGEAL DIVERTICULUM FOLLOWING TRAUMA

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ESOPHAGEAL diverticulum following trauma is an extremely unusual condition. In military medicine esophageal diverticulum of any type is rarely encountered, probably because of the low average age of military personnel. The average age of 140 patients with pulsion esophageal diverticuli reported by Harrington[3] was 57 years. A search of the files of the Armed Forces Medical Library reveals that esophageal diverticulum as a sequel to injury is indeed rare. We were able to find only one case in the recent literature that resulted from external trauma. This case was reported by Grimaud and Courtat.[2] Their patient, a 21-year-old man, was in a bicycle accident and sustained a neck wound with penetration of the esophagus. An abscess formed after the injury and then a fistula appeared followed later by a pharyngo-esophageal diverticulum.

Buxton[1] reported a case that developed in a 59-year-old man following a blast of compressed air in a wind tunnel which occurred when a valve blew out 3 feet from his head. This, of course, represents internal trauma to the esophagus. Another group attributed to trauma has been those cases caused by the swallowing of a large bolus of food. This seems to be a rather remote possibility. However, trauma to the esophageal wall as the result of swallowing such large objects as light bulbs and tennis balls might fall within the realm of circus performers or more likely psychopaths.

War wounds of the esophagus are rarely seen. Undoubtedly, this is due to the fact that in such wounds more vital contiguous structures are also involved and early death ensues. Of 511 patients[4] admitted to a thoracic surgical center (140th General Hospital) in England during 1944 and 1945 there were two instances of esophageal wounds. One case involved the thoracic esophagus and the other the cervical portion of the esophagus. These cases both had short term observation following treatment, and no diverticula were noted.

Esophageal diverticulum resulting following trauma is diagnosed and treated just as any other esophageal diverticulum. The only important operative considerations are the presence of scar tissue, and the fact that these diverticula may arise anywhere in the esophagus.

The following case, in which we feel there is very little doubt about the traumatic origin of the esophageal diverticulum, is presented.

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CASE REPORT

A 22-year-old Puerto Rican soldier was admitted to the EENT Section of Rodriguez Army Hospital on Feb. 2, 1954, with a complaint of difficulty in swallowing. He could swallow liquids with ease but during the six months preceding admission he had encountered increasing difficulty with solid foods. The patient had always been in good health and had never had any serious illnesses. On April 17, 1953, he sustained shell fragment wounds of the right shoulder and neck as a result of enemy action in Korea. Within a few hours the wound of the neck was explored under general anesthesia. Primary closure of an esophageal perforation was carried out. It was also necessary to do a left hemithyroidectomy. There was drainage of food and saliva for a few days following surgery but this soon stopped. From the time of injury the patient's voice was weak and hoarse. Examination of the vocal cords a few days later revealed no cord motion on the left side. His voice improved with speech training on return to the continental United States. Barium swallow two months after injury showed only some displacement of the cervical esophagus to the left but no

Fig. 1.—Left anterior oblique view following barium swallow.

diverticulum. Four months after injury the patient was returned to active duty. At the time of his hospital admission on Feb. 2, 1954, he complained of difficulty in swallowing. The onset of this complaint was dated by the patient as being one or two months following his return to duty in August of 1953. The dysphagia had gradually increased in severity but was related only to solid food. He complained of tasting food he had eaten the previous day.

Physical examination revealed the old traumatic and operative scars on the lower neck and right shoulder. The voice was not hoarse and was of good quality. Laryngoscopy showed that both cords functioned normally in contrast to the findings in the early posttraumatic period. Barium swallow was reported as follows: "Fluoroscopic examination of the esophagus reveals a large diverticulum extending posteriorly from the esophagus. The upper level begins in the base of the neck and the diverticulum extends inferiorly to the level of the superior margin of T_2." (Figs. 1 and 2.) Esophagoscopy revealed the diverticulum beginning 19 cm. from the patient's incisor teeth. The sac extended posteriorly, inferiorly, and to the right. On Feb. 23, 1954, the neck was explored under endotracheal anesthesia

through an incision along the anterior border of the right sternocleidomastoid muscle. The sac of the diverticulum was noted to begin at a point posteriorly 2.5 cm. below the level of the cricoid cartilage. The esophageal defect was approximately 1.0 cm. in diameter. The sac measured 2.5 cm. in length. There was a moderate amount of scar tissue. The diverticulum was excised and the defect closed in two layers using 3-0 black silk. A Penrose drain was left in the wound for three days. There was no subsequent drainage, and he had an uneventful postoperative course. He developed a small keloid which caused some pain in the scar, but there was no dysphagia and barium swallow showed a normal esophagus. He was last seen in February, 1955, at which time he was asymptomatic.

Fig. 2.—Anteroposterior view showing diverticulum extending to the right.

SUMMARY

A case of diverticulum of the esophagus following trauma is presented. A satisfactory result followed one-stage excision.

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ADRENAL APOPLEXY

Case Reports

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HEMORRHAGE into one or both adrenal glands with necrosis, blood loss, and acute adrenal insufficiency, a condition which is almost always fatal, has been reported many times. Chandler[9] quotes Portal in 1769 as the earliest report, and lists many other early ones. Arnaud[4] in 1900, and Lavenson[19] in 1908 extensively reviewed the early literature. Pearl and Brunn[26] in 1928 added a review of twenty cases of bilateral apoplexy since 1908, and added one of their own. Since then there have been several reports and reviews, most frequently involving occurrence during pregnancy.

The cases of adrenal hemorrhage have been classified by age by Dewhurst[10] into those of the newborn, youth (Waterhouse-Friderichsen syndrome), and adults, the latter being subdivided by etiology into those associated with pregnancy, infection, burns, or hypertension. Mac Millan[23] described a physiopathologic classification:

1. Associated with involution or destruction of gland substance as in (a) newborn (involutional), (b) pregnancy, and (c) tumor.
2. Associated with damage to vessel walls by toxemia as in (a) burns, (b) trauma, (c) septicemia, and (d) arteriosclerotic change.
3. Associated with hypertension.
4. Associated with a hemorrhagic tendency as in leukemia or vitamin K deficiency in the newborn.

In reviewing the Anglo-American literature we find many reports of adrenal apoplexy occurring in pregnancy.[5, 8, 10, 11, 16-18, 21, 22, 27] The Waterhouse-Friderichsen syndrome has been well reviewed recently by Anlyan and associates[2] and Ferguson and Chapman.[14] Those cases associated with burns, sepsis other than the fulminating meningococcic type, pancreatitis, thrombophlebitis, and unknown cause are relatively less frequent in the literature and are often associated with thrombosis of the adrenal vein.[1, 4, 7, 19, 20, 25, 26, 35] Simmonds[31] felt that most of these were due to venous thrombosis, as in our second case. Rich[29] called attention to the "tubular degeneration" of the adrenal cortex associated with sepsis, and Wilbur and Rich[34] were able to reproduce this in experimental animals by large doses of corticotropin (ACTH). They feel that this change may precede the hemorrhagic necrosis

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seen in overwhelming sepsis. Exogenous ACTH may be one of the factors responsible for the hemorrhage in the two cases which have been reported associated with ACTH therapy, although Greene's[15] case was also hypertensive, and that of Wilson and Roth[36] was associated with possible sepsis. Plant[28] recently reminded us that small necrotic adrenal lesions occur not infrequently in routine autopsies. There are six cases in the literature possibly due to hypertension,[6, 13, 24, 30, 32, 33] four more clearly so.[7, 12, 15, 23] To this list we add our first case.

Fig. 1.—Gross appearance of cut section of right adrenal (Case 1).

CASE REPORTS

CASE 1.—E. B., C. H. A. Admission No. A279027. This 62-year-old white man presented himself to the Emergency Room with the chief complaint of a continuous sharp pain in his right flank, just above the iliac crest, which radiated into his entire abdomen. This had awakened him one hour earlier. There was no nausea, vomiting, fever or chills, hematuria, or dysuria present although later in the day he did vomit three times. The oral temperature was 98.2° F., the pulse rate 76 per minute, and the blood pressure 156/100 mm. Hg. Several hours later the blood pressure was 198/120 mm. Hg; the pulse rate 126 per minute.

There was a past history of "high blood pressure," recorded as 170/98 mm. Hg six years prior, and some shortness of breath on exertion. There was a clinical diagnosis of carcinoma of the prostate with metastases to the bony pelvis and ribs, first suspected eight years prior to his death. Although a high alkaline and acid phosphatase were present,

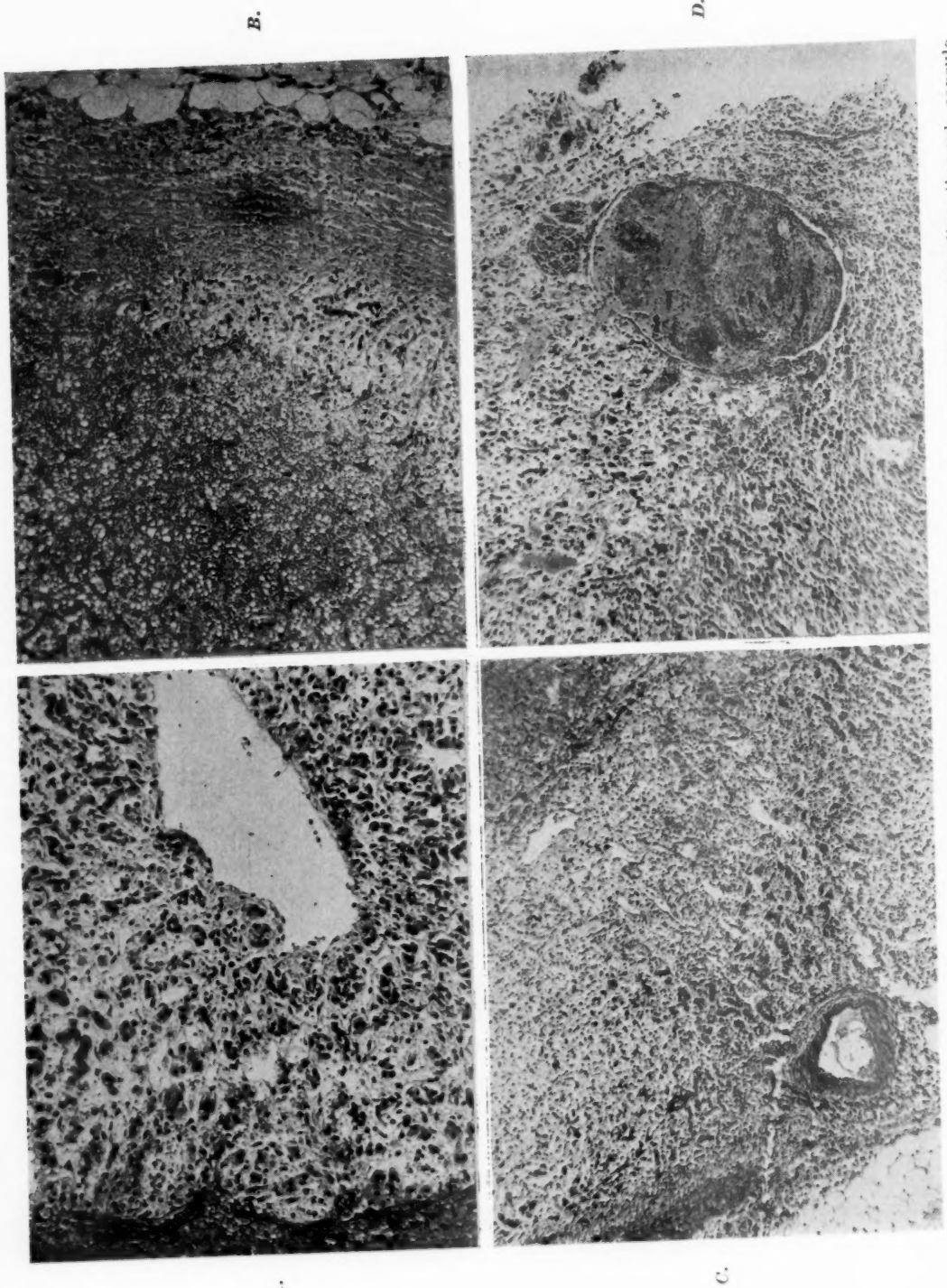

Fig. 2.—*A*, Case 1; central vein, necrosis, and hemorrhage. *B*, Case 1; hemorrhage extending through capsule into periadrenal fat. *C*, Case 1; congestion, necrosis, and hemorrhage. Note sclerotic arteriole. *D*, Case 2; partly organized thrombus in central vein.

a transrectal biopsy of the prostate failed to reveal neoplasm. He received estrogen therapy, a short course of cortisone, and orchiectomy, the latter two within a few months of his death and at another hospital.

The positive findings on physical examination were the elevated pulse rate and blood pressure, moderate right lower quadrant abdominal tenderness to palpation, and rebound tenderness referred to the right lower quadrant from all quadrants. Bowel sounds were active. Urine examinations revealed 1+ albumin and from 0 to 3+ reducing sugar, with many leukocytes, occasional erythrocytes and granular casts, and some bacteria in the sediment. The leukocyte count rose from 10,500 to 12,700 per cu. mm. blood with 80 per cent neutrophils.

With the provisional diagnosis of acute appendicitis, laporatomy was performed. On opening the abdomen 50 ml. of sanguineous fluid was found, and a normal appendix. There was a large retroperitoneal hematoma beneath the base of the ascending portion and hepatic flexure of the colon. Drains were inserted and as the condition was then considered to be a ruptured aortic aneurysm the abdomen was closed.

The patient lived five days after surgery. The temperature rose gradually to 105° F. (R) terminally, along with the pulse and respirations. At first the frequent episodes of hypotension were corrected by blood transfusions until terminally, when blood and infusions of nor-epinephrine could not correct the shock.

Necropsy (A-176-54) revealed arteriolar nephrosclerosis, hypertrophy and dilatation of the heart (490 grams), and generalized acute passive congestion. There was generalized arteriosclerosis, but there was no defect in the aorta or renal or other artery or vein in the abdomen that was large enough to be traced. There was a soft hematoma in the right adrenal (Fig. 1) with extention beyond the capsule into the periadrenal tissue, forming the hematoma noted at surgery. The left adrenal appeared grossly normal. Firm cancellous bone resembling the calcified callus of an old fracture was found on one rib. The prostate was small and grossly normal with no unusual attachment to near-by structures.

Microscopically the right and left adrenal veins were free of thrombi. A partially organized hematoma in the right adrenal extended into the retroperitoneal fat tissue. There was extensive congestion, retrogressive changes, and necrosis in the remaining cortical and medullary tissue of the right adrenal, and lipid depletion and edema of the left adrenal cortex (Fig. 2). Although adenocarcinoma with extensive fibrosis was found in the prostate, no metastases were found in either adrenal or elsewhere. The pelvic bones were not examined.

Case 2.—R. W., C. H. A. Admission No. A221093. This 74-year-old white man entered the Emergency Room with the chief complaint of a painful nonreducible right inguinal hernia. The pain had been present two days. The oral temperature was 98° F., the pulse rate 100 and the respirations 26 per minute, and the blood pressure 142/94 mm. Hg. There was no history of cardiorespiratory difficulties. A right herniorrhaphy was performed with resection of an infarcted segment of small bowel and the right testicle, and end-to-end anastomosis of the remaining small bowel. The patient's condition deteriorated, accompanied by fever, abdominal distention, and a disoriented state, and he expired after four days.

At necropsy (A-228-51, performed by Dr. Mary Dufner), there was acute purulent confluent lobular pneumonia, moderate hypertrophy of the heart (510 grams), an intact anastomosis in the small bowel, and focal hemorrhages in both adrenal glands. Microscopically there was slight arteriolar nephrosclerosis, generalized passive congestion, and confirmation of the pneumonia. There were areas of hemorrhagic infarction in both adrenals with early organizing thrombi in the adrenal veins (Fig. 2).

DISCUSSION

Anson and associates,[3] after careful study of numerous cadavers, found that while the adrenal gland is drained by one vein on either side there are up

to 50 arteries supplying each gland. These are branches of the phrenic and renal arteries, and the aorta. They arborize at or near the capsule of the gland and supply the cortical sinusoids. Thus thrombosis of the vein or rupture of any of the small arteries might produce hemorrhage into the gland parenchyma.

Our first case is unusual in that it presented itself as a possible acute appendicitis, without signs of shock early in the course. Furthermore, hypotensive episodes responded to blood replacement until terminally, indicating that perhaps adrenal function was adequate. This course is more common in the hypertensive patients than in those associated with pregnancy, perhaps because of the increased output of circulating corticoids during pregnancy associated with adrenal cortical hyperplasia.[27] There have been two cases reported which recovered after surgery.[12, 25] One might presume that if a hemorrhagic gland were removed and the bleeding stopped that recovery might ensue. However it is usually difficult or impossible to determine the site of extensive retroperitoneal hemorrhage.

Our second case represents a more common form of hemorrhage into the adrenal gland, focal infarction following venous thrombosis secondary to sepsis. One can only hypothesize how this abnormality added to the difficulties the patient was enduring.

SUMMARY

Two cases of hemorrhage into the adrenal gland are presented. One, which led directly to the patient's demise, is assumed to be due to the rupture of an artery within the gland because of hypertension and perhaps other unknown factors, such as focal damage due to arteriosclerosis. Another, which followed surgery and sepsis in an elderly dehydrated patient, resulted from thrombosis of the adrenal vein and was only one of the factors which led to the death of this patient. The literature is briefly reviewed and the various factors leading to adrenal apoplexy are discussed.

We wish to thank Mr. John Muldowney of The Dr. Walter A. Hoyt Studio of Medical Photography for the illustrations.

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ADDENDUM

Since submission of this paper we have found in the literature another case of unilateral (left) adrenal apoplexy, evidently due to arteritis, which was operated upon with survival.* A fifth case of unilateral adrenal hemorrhage (right) clearly due to hypertension has also recently been reported.†

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RIGHT LOBECTOMY OF THE LIVER IN CHILDREN

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PAST surgical experiences with primary tumors of the liver in infancy and childhood have left a dismal record. Fortunately, today, with enhanced technical developments and a greater understanding of the inherent processes of the liver, a more aggressive attitude toward the surgical therapy of these lesions is desirable and justified. It is our purpose to encourage an enthusiastic effort to salvage small patients afflicted with benign or malignant tumors of the liver by describing the surgical technique and by demonstrating the feasibility of total right hepatectomy.

One of the two case reports which form the nucleus of this paper is believed to be a record of the earliest case yet reported in which a total right hepatectomy was performed for a primary neoplasm. In this and in our subsequent case an anatomic dissection permitted resection of the entire lobe of the liver without great technical difficulties or hazard.

CASE REPORTS

Case 1.—This 17-month-old white boy was admitted to the Columbus Children's Hospital on March 26, 1952, because of an abdominal tumor. He appeared to be in good health until six weeks before admission at which time he developed an illness characterized by fever, irritability, anorexia, and loss of weight. At this time it was first noticed that his abdomen was enlarged and this enlargement became progressively more pronounced until hospitalization. On physical examination, the child was thin (weight 22 pounds) and pale, with a markedly protruding abdomen. His vital signs were normal and with the exception of evidence of recent weight loss the positive physical findings were limited to the abdomen. A large, firm, smoothly rounded mass was palpable in the right upper abdomen. This extended across the midline, moved with respirations, did not transilluminate, and could not be separated from normal liver.

Radiographic studies demonstrated a soft tissue mass in the right side of the abdomen extending from the level of the elevated right leaf of the diaphragm to the iliac crest. No areas of calcification or decreased density were noted within the mass. Intravenous pyelograms showed both kidneys to be in the normal position, but there was marked anteroposterior compression of the pelvis and calyces on the right side (Fig. 1). Barium studies showed displacement of the stomach to the left and the duodenum was pushed downward and to the left of its usual position. The hepatic flexure of the colon was also displaced downward. No osseous or pulmonary metastases were demonstrated. The hemoglobin value on admission was 9.3 Gm. and preoperatively this was raised to 14.7 Gm. by blood transfusions. The prothrombin time and serum van den Bergh were normal before surgery.

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Primary hepatoma was considered the most probable diagnosis and neuroblastoma with liver invasion the next most likely. On April 1, 1952, a surgical exploration was carried out under orotracheal nitrous oxide-ether anesthesia. The abdomen was opened through a long supraumbilical transverse incision and a huge tumor involving over two-thirds of the right lobe of the liver was found. There was no evidence of tumor in the left lobe of the liver, although in the region of the hepatic veins the mass seemed to bulge across the midline. No hilar nor other nodes were involved and it was felt that this solid tumor was resectable.

The structures at the hilum were then carefully dissected with exposure of the hepatic artery, the hepatic ducts, and the portal vein and their respective branches to the right and left lobes of the liver. The gall bladder was removed in the routine fashion. The right lobe of the liver was then rotated upward and to the left. In order to obtain adequate exposure of the superior hepatic veins, it was necessary to extend the incision upward into

Fig. 1.—Intravenous pyelogram (margins outlined) showing compression of right renal pelvis calyces from overlying tumor mass.

the right eighth intercostal space transecting the diaphragm obliquely downward to the vena cava. All hepatic veins to the right lobe were carefully exposed, doubly ligated, and divided close to the vena cava. The right hepatic artery, the right hepatic duct, and the right main portal vein branch were then ligated and divided in the hilum. Several interlocking mattress sutures of 3-0 black silk were placed through the inferior (thin) edge of the liver. The liver just to the right of the midline was cut through. The major blood vessels and biliary radicals were individually clamped and ligated as they were encountered. A pad of Gelfoam was placed on the cut surface to aid hemostasis. In

order to reperitonealize the liver face, the falciform ligament was turned down to cover as much of the raw area as possible and this was reinforced by the omentum and the transverse colon. A small Penrose drain was led down to the reperitonealized face of the liver and the wound was closed in layers. Approximately, 1,500 c.c. of whole blood was given during the procedure and the immediate postoperative period (measured blood loss 1,540 c.c.).

The resected right lobe measured approximately 15 by 12 by 10 cm. and was almost totally replaced by nodular, solid, gray-white tumor tissue with but a small portion of uninvolved liver present (Fig. 2). Microscopic examination showed very clear cells arranged in cords resembling liver structure. The cells contained large amounts of cytoplasm and hyperchromatic oval-shaped nuclei. The adjacent liver tissue showed proliferation of the bile ducts with some fibrosis. The final pathologic diagnosis was hepatoma (liver-cell carcinoma).

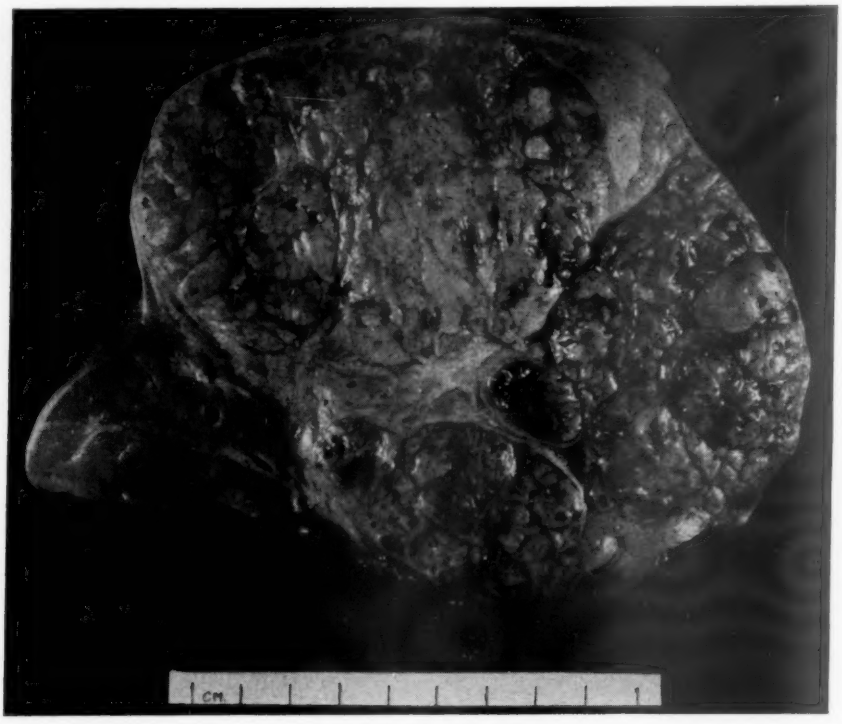

Fig. 2.—Resected right lobe of liver in Case 1, illustrating almost complete replacement of hepatoma.

The patient had a difficult postoperative course. The drain along the face of the liver was prematurely removed and bile apparently seeped from the raw liver surface. On the eleventh postoperative day an intraperitoneal collection of bile was drained. Intermittent episodes of ileus, presumably on the basis of a bile peritonitis, continued for three weeks after surgery. Thereafter, the boy made a gradual recovery and was discharged on the thirty-sixth postoperative day.

Repeated liver function tests were obtained during the postoperative period, including serum protein, albumin and globulin, van den Bergh, prothombin time, total cholesterol and esters, cephalin flocculation, and thymol turbidity. All remained within normal limits except for the van den Bergh which became elevated after operation and remained so until discharged (twenty-fourth postoperative day: direct 9.9, indirect 7.3, total 17.2 mg. per cent). Postoperatively, the left lobe of the liver increased tremendously in size so that it was easily palpable and filled most of the epigastrium.

Following discharge from the hospital, the patient did well at home for five weeks. During this time his jaundice completely disappeared, his appetite returned to normal, and he gained in weight from 22 pounds to 27 pounds. However, at the end of this period and two and one-half months following the surgery, he developed an acute episode with vomiting and abdominal distention and expired after an illness of only two days. Unfortunately, the patient was not readmitted to the hospital during this terminal illness for treatment, and an autopsy was not performed.

CASE 2.—This 5-month-old white male infant was admitted to the Columbus Children's Hospital on Feb. 23, 1953, because of an abdominal enlargement. Two weeks before admission enlargement of the upper abdomen was first noted in this otherwise healthy infant. The patient gave no evidence of pain and his feeding and development had been perfectly normal. On physical examination, the infant was well developed and well nourished with the positive findings being limited to the abdomen. A soft rounded mass which extended below the costal margin for a distance of approximately 10 cm. was palpable in the right upper quadrant. The mass moved with respiration and was faintly transilluminable. Because of this latter finding, a lymphangioma was strongly suspected.

Fig. 3.—*Left,* Upper gastrointestinal series with displacement of duodenum to the left; *right,* intravenous pyelogram (margins outlined) showing downward displacement of right kidney. Huge soft tissue mass in right upper quadrant clearly illustrated.

Preoperative laboratory data, including total protein, prothrombin time, cephalin flocculation, and thymol turbidity, were all normal. A recumbent radiographic film of the abdomen showed a large mass in the right upper quadrant which could not be separated from the liver. The right kidney was demonstrated by intravenous pyelography to be displaced downward and an upper gastrointestinal series showed the duodenum to be displaced to the left (Fig. 3). The routine chest and skeletal survey showed no distant metastases.

On the fifth hospital day, under orotracheal nitirous oxide-ether anesthesia, surgical exploration through a transverse supraumbilical incision was performed. A huge cystic mass involving 75 to 85 per cent of the right lobe of the liver was found. The tumor had a thick capsule with several large superficial veins. The gall bladder lay on the medial side of the mass and there was no evidence of tumor in the porta hepatis. Since this appeared

to be a benign tumor and amenable to surgical extirpation, an extension of the incision was carried through the eighth right intercostal space. After dividing the diaphragm to the vena cava and incising the right triangular ligament, an excellent exposure was obtained.

Resection of the right lobe proceeded in an anatomic manner. After separating the right lobe posteriorly from an area of adherence to the adrenal gland, a band of liver tissue approximately 1½ inches in length and ½ inch in thickness was encountered which encircled the vena cava. This band was carefully dissected free and transected between four mattress sutures, thus exposing the vena cava. The multiple hepatic veins were then exposed, ligated,

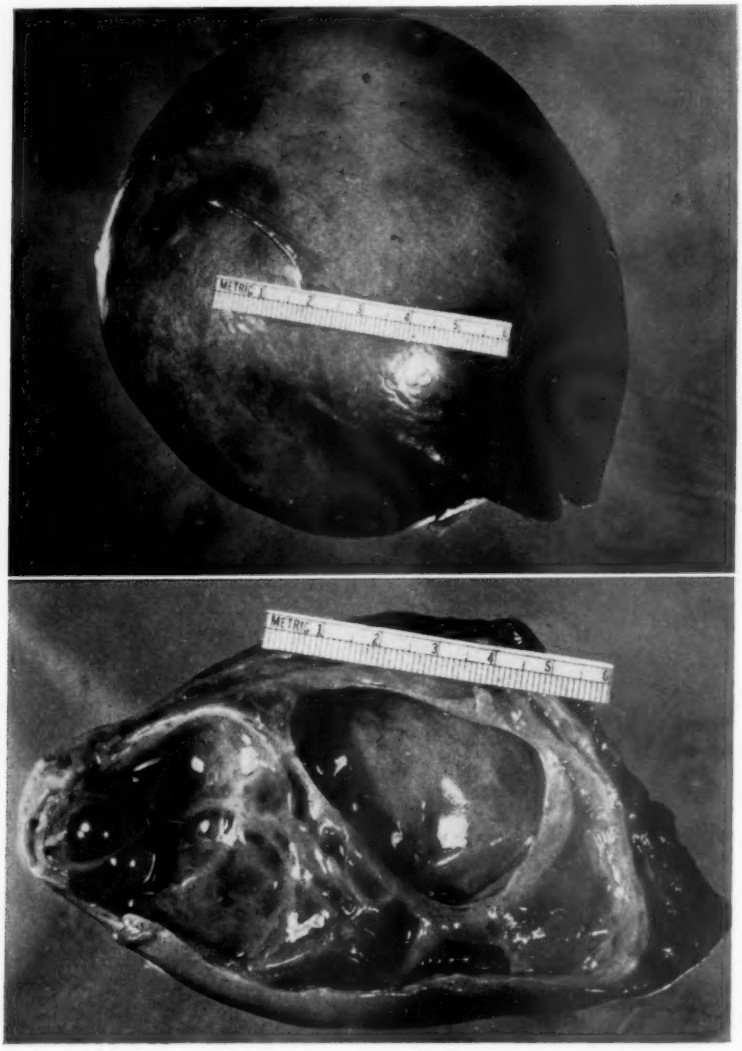

Fig. 4.—Resected right hepatic lobe in Case 2. Lower photograph (with specimen sectioned) shows the multilocular cystic structure of the lymphangioma.

and divided. The gall bladder was purposely not removed but freed from the liver with its blood supply. Hemostasis was achieved by placing multiple mattress sutures of 3-0 silk through the inferior free edge of the substance of the liver along the line of the resection. In order to further control blood loss at the time of resection, the entire thickness of the hepatoduodenal ligament (including all major afferent blood vessels and ducts) was temporarily occluded (six minutes) with a Potts aortic clamp while the right lobe was removed

by sharp dissection. The major vessels and bile ducts were grasped with hemostats as the dissection progressed through the normal liver substance. Further hemostasis of the liver face was achieved after removal of the Potts clamp. A small urethral catheter was then introduced into the gall bladder through which saline solution colored with methylene blue was injected. Thus, with the common duct occluded, it was possible by retrograde injection to demonstrate a number of open biliary radicals on the cut surface of the liver and these were painstakingly ligated. A large piece of Gelfoam was then placed over the raw surface of the liver and this area was completely reperitonealized by utilizing the turned-down falciform ligament anteriorly, the turned-up perirenal fascia posteriorly, and the stretched-out gall bladder inferiorly and medially. The cholecystostomy tube and a cigarette-drain left in the subdiaphragmatic area were brought out through the flank and the incision was closed with interrupted silk. There was 1,180 c.c. of whole blood given for a measured (weighed) blood loss of 1,100 c.c.

The removed specimen consisted of a globular mass which had the gross appearance of swollen liver and weighed 510 grams. The mass was sectioned and found to be a cystic tumor surrounded by thin capsule or wall of normal liver substance (Fig. 4). The tumor consisted primarily of large dilated spaces which were multilocular and contained clear serous fluid. The cyst linings consisted of thick, white fibrous connective tissue which in many areas showed a thin unicellular endothelial layer. The final pathologic diagnosis was benign lymphangioma of the liver.

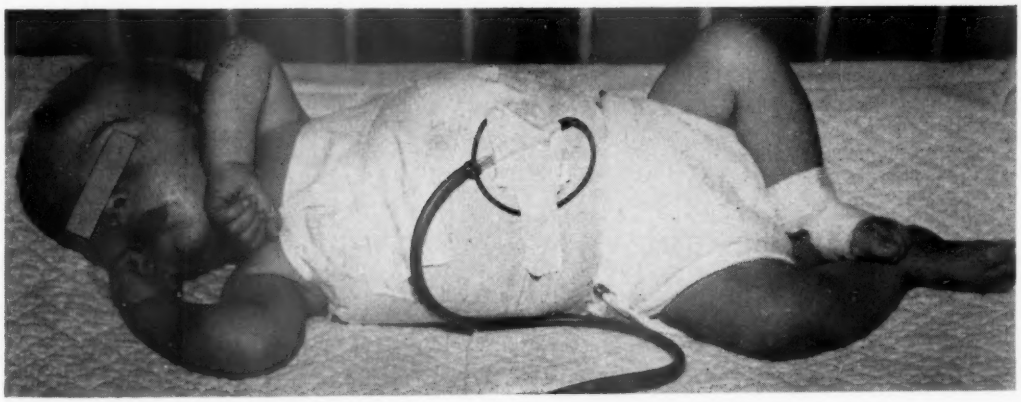

Fig. 5.—Photograph of patient (Case 2) on third postoperative day. Cholecystostomy tube still in place.

Postoperatively, the patient's course was very satisfactory and without complications (Fig. 5). Following a a cholangiogram, the drain and cholecystostomy tube were removed on the eleventh postoperative day and the patient was discharged two days later. Repeated checks on the various liver function tests, including total protein, albumin and globulin, serum cholesterol, cephalin flocculation, thymol turbidity, van den Bergh, and prothrombin time, showed no abnormalities. The child has remained entirely well and has been able to maintain a normal growth increment (Fig. 6).

DISCUSSION

Reported experiences with primary liver neoplasms from large pediatric centers have been discouraging. Of 18 such tumors cited by Gross,[1] all were surgically explored and biopsied but in only 5 was resection performed. Only 2 of the 18 have survived, one with multiple hemangiomas which were treated by radiotherapy and the second with a small hamartoma which was successfully

excised. Anderson[2] reported 12 primary livers seen over a sixteen-year period with but 1 survivor. In this latter instance a mesenchymoma of the left lobe was successfully removed and six years later the child remained well.

It seems likely that these results will be strikingly bettered in the future. Resection of the left lobe of the liver has been successfully accomplished many times and more recently Wangensteen,[3] Lortat-Jacob and Robert,[4] Quattlebaum,[5] Brunschwig,[6] Pack and Baker,[7] and Lorimer[8] have successfully accomplished a right hepatectomy for metastatic carcinoma, granuloma, or primary neoplasm in adults.

Fig. 6.—Patient (Case 2) two years after total right hepatectomy for lymphangioma of the liver. Growth and laboratory tests normal. Note well-healed scar.

When performed for primary disease, such resections conform more closely to the standards of adequate tumor surgery and may be expected to give better long-term results than less formidable procedures such as enucleation or limited resection.

Fear of excessive blood loss and liver insufficiency from such resections has been largely overcome. The use of an anatomic technique in handling the hepatic veins and temporary occlusion of the porta hepatis lessen the first hazard to a reasonable risk. It has been demonstrated both in the experimental animal laboratory and in clinical cases that such resections leave adequate hepatic tissue for their necessary vital functions.[3-8]

Satisfactory exposure for resection of the right lobe requires a combined thoracoabdominal approach. In both of the presented cases a transverse supraumbilical or subcostal incision was first made. Through this incision a complete abdominal exploration was performed with confirmation of the diagnosis and determination of operability. This incision was then joined by a thoracic incision in the right eighth intercostal space, incising the diaphragm down to the vena cava and thus widely opening the right thoracoabdominal area. Such a method allows exploration without thoracotomy, gives excellent exposure for all phases of the procedure, allows displacement of the right lobe forward, upward, and to the left while dealing with the hepatic veins, and heals well (Fig. 7).

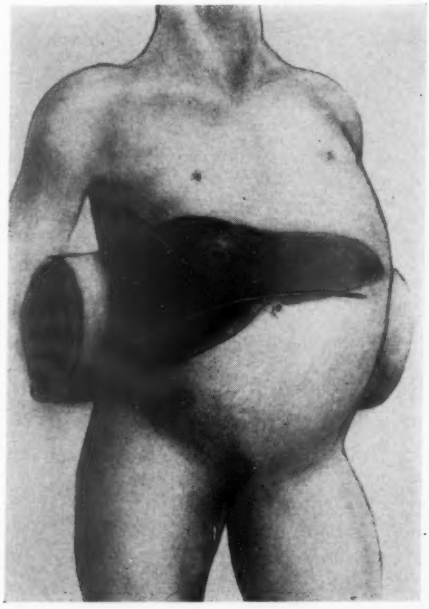

Fig. 7.—Supraumbilical transverse incision used for initial exploration and determination of resectability. This is later joined by an incision through the eighth right intercostal space for necessary exposure.

Hemostasis is achieved by dissection of the hilus of the liver with ligation and division of the right hepatic duct, the right hepatic artery, and the right portal vein. The gall bladder is enucleated from its liver bed but is purposely not removed since it is used in the retrograde injection of the biliary tree later in the operation. The right lobe can then be rotated upward and to the left, resting partially in the right chest. By this maneuver, access is obtained to the 6 to 10 short hepatic veins running from the right lobe into the vena cava. These are carefully and individually exposed, ligated, and divided. This step

is most important in avoiding serious hemorrhage or air embolism later in the operation (Fig. 8). Additional hemostasis from the free edge of the left lobe is obtained by cross-clamping the remaining hepatoduodenal ligament for a few moments with a Potts type ductus clamp. Visible blood vessels and bile ducts are individually clamped and ligated as the liver is transected with a scalpel. The placement of a row of mattress sutures to the left of the plane of division prior to resection may be of advantage but it is not essential.

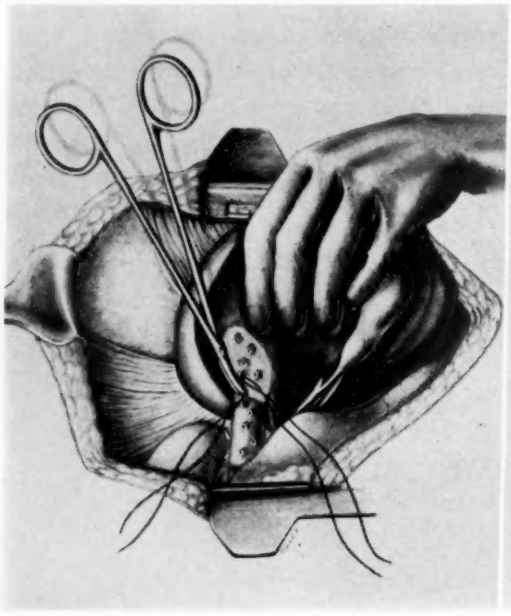

Fig. 8.

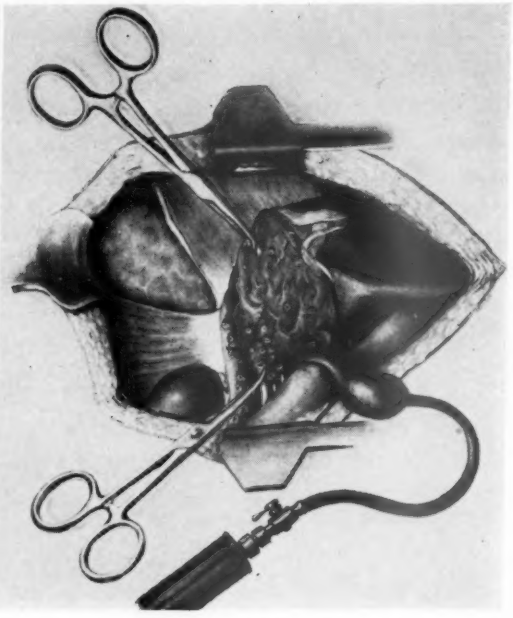

Fig. 9.

Fig. 8.—Right lobe of liver retracted forward, upward, and to the left. Hepatic veins exposed and divided.

Fig. 9.—Resection of right lobe completed with individual ligation of hepatic vein, artery, and duct. Retrograde injection via cholecystostomy tube of methylene blue solution to visualize open bile ducts on cut surface.

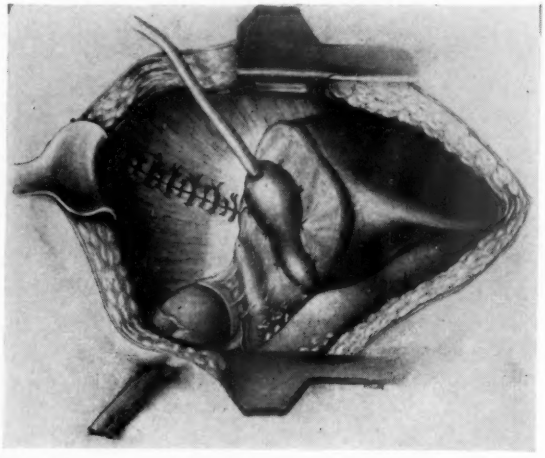

Fig. 10.—Peritonealization of cut surface of liver accomplished with turned-down falciform ligament gall bladder, and turned-up perirenal fascia mobilized from kidney.

Bile leakage is further minimized by placing a small catheter into the gall bladder and, with the common bile duct temporarily occluded below the cystic duct, performing a retrograde injection of the intrahepatic biliary tree via the cholecystotomy with saline solution colored by a few drops of methylene blue (Fig. 9). By this means, additional open biliary radicles on the raw liver surface are detected and ligated, thus obviating bile leakage and the danger of bile peritonitis.

Reperitonealization of the raw surface is accomplished insofar as possible with the falciform ligament, the stretched-out gall bladder, and the mobilized peritoneum overlying the kidney. Penrose drains are left adjacent to the divided liver surface (Fig. 10).

A number of successful resections of the right lobe have been reported since our first case was operated upon[3-8] and they demonstrate that in adults the remaining liver tissue is adequate for satisfactory hepatic function. In most instances the right lobe was largely replaced by tumor so that the resections removed only a relatively small portion of normal tissue. In the first of our cases, surgery was followed by icterus presumably due to bile peritonitis which gradually disappeared over the course of several weeks. Other liver function studies were normal. In the second case, there was no laboratory nor other evidence of liver impairment.

SUMMARY

Two cases of resection of the entire right lobe of the liver for neoplasm in young children, one 17 months and the other 5 months of age, are presented.

In the first case in which the right lobe was largely replaced by a hepatoma, the patient's postoperative course was complicated by bile peritonitis and jaundice. After recovery of good health and vigor, the child expired after a brief illness two and one-half months following surgery. The second child had an uneventful recovery after resection for a massive lymphangioma.

A detailed description of the operative technique is given. The advantages of a wide exposure by a combined thoracoabdominal approach and of an anatomic type of dissection are stressed.

Adequate hepatic function without demonstrable impairment may be expected to follow such resections.

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ACUTE DUODENAL OBSTRUCTION SECONDARY TO INTRAMURAL HEMATOMA

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ACUTE duodenal obstruction secondary to intramural hematoma is an uncommon occurrence. A recent pediatric case with an acute abdomen of obscure origin directed our attention to this condition. Diagnosis of the acute abdomen in the child may be clouded by many factors such as unheeded trauma, problems in communication, late-appearing congenital defects, abdominal manifestations of systemic disease, inflammatory visceral disease, and functional overlay. The surgeon who attends children will recognize the difficulties presented by our patient.

CASE REPORT

An 11-year-old white boy was admitted on the Pediatrics service of Minneapolis General Hospital Nov. 24, 1954, with complaints of vomiting and epigastric pain. Historically he was well until forty-eight hours prior to admission, when he was sent home from school because "he didn't look well." On the way home he became nauseated and vomited. During the subsequent two days he continued to vomit all oral intake. During the day prior to admission he complained of "pain in the stomach" of a generalized, steady character. His mother noted that he "kept his knees drawn up to his stomach" whether awake or asleep. A bowel movement two days previously was normal, but he had had none since. The urine had shown no color changes. On the day of admission he was taken to a private physician who stated that he was severely dehydrated and possibly had appendicitis, and arranged admission to this hospital.

Developmental history was normal. A schoolmate was known to have had "yellow jaundice" one month before. The remainder of his history was not remarkable. There were no recent parenteral administrations nor contact with hepatotoxins.

Physical examination upon admission found a quiet, alert, cooperative boy in no distress at rest. The temperature was 37° C. orally, pulse 120, respirations 20, and blood pressure 110/80. The skin was warm and dry with "spider nevi" noted on the face and right forearm. There was no suggestion of icterus. The eyes were sunken, lips dry and cracked, tongue coated but moist, breath fetid, and a mild gingivitis present. Chest was normal. The abdomen was scaphoid, with a firm, tender mass interpreted as "liver margin" palpated four fingerbreadths below the right costal margin. Bowel sounds were absent. There was "no rebound tenderness." The remainder of the examination was normal and the admission impression was infectious hepatitis, with marked dehydration. Infectious mononucleosis was considered a possibility.

Bed rest, parenteral fluids, and diagnostic work-up were begun.

Laboratory work on admission showed a hemoglobin of 15.6 grams per cent, leukocyte count 16,600 per cu. mm., with 94 per cent neutrophiles, 5 per cent lymphocytes, and 1 per

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cent monocytes; hematocrit 53 vol. per cent; erythrocyte sedimentation rate 5 mm. per hour. Urinalysis was normal with a specific gravity of 1.031. Carbon dioxide combining-power and serum chlorides were normal. Serum bilirubin was 0.68 mg. per cent total, and thymol turbidity and urine urobilinogen showed no deviations. Serum amylase on November 30 was 162 Somogyi activity units. Chest roentgenogram was normal.

There were daily temperature elevations of one degree and vomiting of anything taken by mouth. Bowel sounds continued hypoactive or absent. The right upper quadrant mass remained the same, with mild to moderate epigastric tenderness.

Fig. 1.—Oblique view Nov. 29, 1954, demonstrates the markedly dilated third portion of duodenum, with the coil-spring appearance, felt to be characteristic of intramural hematoma of the duodenum.

The normal liver profile and leukocytosis, with signs of high obstruction, prompted further inquiry into the possibility of trauma. Upon close questioning of the parents it was recalled that the patient had been struck hard enough in the abdomen to make him stop playing football on the day prior to the onset of his illness. This resulted in a mild epigastric pain which radiated through to the back. He appeared mildly lethargic that evening. The boy remarked once that "his stomach stuck out in a funny way."

A flat film of the abdomen on November 26 was normal except for a fluid-distended stomach. Continuous gastric suction was begun. Intravenous pyelography showed questionable lateral deviation of the upper right ureter. Retrograde pyelography confirmed this find-

ing. Barium study on November 29 demonstrated distortion of the third portion of the duodenum (Fig. 1). A puddling of the barium was first noted fluoroscopically, followed by a distended "coil-spring" effect suggestive of intussusception. With some delay the barium left the area, passing into the small bowel without evidence of other abnormality.

At laparotomy on December 3 an intramural hematoma of the third portion of the duodenum, 8 by 12 cm. in size was found. The mass was purplish, fluctuant, extended to the ligament of Treitz, and overlaid the head of the pancreas superiorly. The adjacent kidney was not displaced, but the upper one-third of the right ureter was mildly deviated laterally by the mass. The transverse duodenum was approximately three times normal size. Conservative management was elected and the abdominal wound closed without drainage.

Fig. 2.—Oblique view May 2, 1955, shows the nearly normal duodenal outline following clinical recovery from the duodenal hematoma.

The postoperative course was benign. Three days later with development of bowel sounds, a soft rubber catheter was threaded transnasally into the jejunum, and high caloric, high protein gavage feedings begun. Two weeks postoperatively oral feedings were begun gradually and were well tolerated. The patient was discharged to the surgery out-patient clinic December 24 doing nicely. Barium study on May 22, 1955, found the duodenum quite distensible, with but minimal evidence of abnormality (Fig. 2). The patient was asymptomatic and on full activity.

DISCUSSION

Intramural hematomata of the bowel have received occasional attention in the literature. Liverud[5] reported a case involving the proximal jejunum, and referred to reports indicating bleeding tendencies as a cause. Cases of operative needle trauma, traumatic reduction of an incarcerated hernia, and ileal hematoma associated with a mesenteric cyst were also cited. Oppenheimer's[7] case occurred as a complication of duodenal invasion by pancreatic neoplasm. Dey[1] reported a case with duodenal obstruction of unknown etiology in a 6-year-old child. Felson and Levin[2] found four cases affecting the duodenum in Cincinnati, three of which had a history of trauma to the abdomen. Magladry and Carleton[6] also published a post-traumatic case in a 9-year-old boy.

Clinically, the intramural duodenal hematoma usually follows a history of abdominal trauma, often relatively mild. Symptoms and findings are those of a high intestinal obstruction. X-ray findings have been thoroughly reviewed by Felson and Levin,[2] who feel that the roentgenologic outline of an intramural mass by barium, in association with a "coil-spring" mucosal pattern, is pathognomonic of hematoma of the duodenal wall. The characteristic radiographs are seen in the accompanying illustrations.

Most of the cases reviewed received surgical attention. The duodenal hematoma is a mixture of liquid and clotted blood, frequently associated with retroperitoneal hematoma (on one occasion extending down into the ascending colon, cecum, appendix and terminal ileum).[6] Pancreatic injury is present in some. Evacuation with primary closure was usually effected with excellent results. Most commonly the intramural duodenal collection was in the second and/or third portions terminating at the ligament of Treitz.

Following this study, it is felt by the author that evacuation of the hematoma will usually be the procedure of choice. Probably most would be successfully absorbed, but in one instance of intramural hematoma of the descending colon exploration eight months after injury found the lesion firm and rubbery, with quite dense adhesions and shortening of the mesentery.[3] The danger of infection is probably greater without evacuation. It also seems likely that complete recovery is hastened by surgical evacuation of the collection.

SUMMARY

Duodenal obstruction secondary to intramural hematoma is uncommon. A case is presented, with a review of the literature. Symptomatology, diagnostic measures, and the rationale of surgical treatment are discussed.

I should like to thank Dr. Tague Chisholm for guidance and advice throughout both case and paper.

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Recent Advances in Surgery

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RUPTURE OF THE ESOPHAGUS

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(Continued from the April issue, page 709)

CLINICAL PICTURE

> To vomit is one of the very disagreeable, indescribable sensations that most of us experience at some time in our life. It has usually been considerd an innocent physiologic process . . . it . . . may be the cause of one of the most catastrophic diseases of man—Mulsow.[103]

No age is immune but instances are most common in middle life and old age (Table VII). There is a clear-cut preference for the male sex as five-sixths of all cases reported occurred in men. Although there is no reason to suppose Negroes are less susceptible to the accident, the ratio is one Negro to nine white (16 of 157). However, this apparent discrepancy is believed to stem from the relatively large number of European reports.

TABLE VII.—AGE AND SEX DISTRIBUTION OF 157 INSTANCES OF RUPTURE OF THE ESOPHAGUS

AGE IN YEARS	UNDER 1	1-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	NOT GIVEN	TOTAL
Male	2	4	2	8	18	27	31	19	11	6	128
Female	2	2	4	2	3	4	6	3	2	1	29
Total	4	6	6	10	21	31	37	22	13	7	157

The onset is usually sudden. The patient has indigestion following an excess of food or drink, and while retching or vomiting he is abruptly seized with violent pain in the epigastrium or precordium. The onset may be so fulminating that poisoning is suspected; in the case described by Raestrup[117] the police ordered an autopsy on the request of the relatives. Similarly, mineral poisoning was seriously considered as a possibility in the case of Charles.[27] At times there is a sensation of something having torn or given way.[13, 27, 64, 107, 112] Patek's[107] patient, a strong athletic young man, after eating excessively and rapidly, felt a sensation of fullness in the epigastrium, inserted his finger in his mouth to induce vomiting, and cried out in great agony, "Something has broken. I heard it and I *felt* it. Air! Doctor!"

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The vomiting need not be related to meals to cause the rupture but may be a component of hyperemesis gravidarum[116] or seasickness.[130] The patient of Beal[11] became nauseated and vomited while straining at stool. Cohn's[31] patient was experiencing gastric lavage; there was about 750 c.c. of fluid in the stomach when, with a sudden choking motion, the tube was thrown out, and simultaneously a wave of bloody fluid came from the mouth.

Although vomiting almost invariably precedes the catastrophe, there are a number of instances recorded in which there either was no vomiting[71, 77, 81, 114, 138] or in which pain preceded.[102, 103] In Anderson's[5] third case, the patient noticed his face swell up during the meal; later he felt severe cramping abdominal pain.

The pain is located equally frequently in the epigastrium or precordium. It may be felt deep within the abdomen or chest, in the lumbar region, or along the vertebral column. It is not unusual for the pain to encircle the victim at the level of the diaphragm. The pain is described as "knifelike," "stabbing," and "coup de poignard," and is of such intensity as to require large quantities of opiates. There is a tendency for the pain to become more severe and to have a wider radiation as more of the irritating gastric contents are discharged into the chest. It is worsened by breathing, and respiration tends to be rapid and shallow. The discomfort is lessened by immobility; certain patients have had most relief by sitting or being held half erect, bowed forward. Thus, Boerhaave[13] found the Baron de Wassenaer sitting in bed with his body bent forward almost double. Three servants supported him in this attitude as every other posture especially sitting or standing upright caused excruciating agony. Similar postures were assumed by the patients of Desjardins,[37] of Habershon,[61] and of Gramatzki.[54] These less fortunate victims had no servants to help. Flexure of the knees on the abdomen is extremely common. Ridgway and Duncan[118] did not turn their patient for examination "because of the agonizing pain."

The pain is worsened by swallowing, especially if brandy or the like is given. The patient of Desjardins[37] drank some coffee to attenuate the pain. The effect surpassed his expectations, but in an opposite sense. Depending on the size of the esophageal rent, a greater or lesser amount of the material swallowed enters the mediastinum or pleural space. If swallowing is followed by coughing, this speaks for a tear of the pleura.[62, 110]

The pain may be associated with tenderness or rigidity of the abdominal wall, especially in the epigastrium or the right or left upper quadrants. The diagnosis of perforation has been frequently made in those patients who had had symptoms of peptic ulceration in the past.

Thirst may be outstanding[55, 56, 115, 143] but is not usually commented upon. The face becomes pale, extreme anxiety and angor animi may set in. Varying degrees of shock, acute collapse, or even coma may supervene. More generally there is a progressive deterioration over the next few hours. Dyspnea makes its appearance in almost all instances and may be severe, progressing to orthopnea. Cyanosis is very common.

Several writers have noted alteration of the quality of the voice. In Harrison's[64] patient the tone became higher pitched and in Soupault and Couinaud's[134] patient the voice became hoarse. Samson[125] commented on the fre-

quency of nasal twang which "may be of extreme importance since it often precedes the appearance of neck crepitation by several hours." Pain may interfere with speech or may cause such groaning as to render stethescopic examination impossible.

Particularly characteristic is the appearance of subcutaneous emphysema, ordinarily first observed in the neck just above the collar bones. It progresses slowly, usually remaining confined to the upper part of the body. It may be completely absent. Ware, Shnider and Davis[142] make the point that if emphysema is to occur it will be first noted in the mediastinum. Since its presence here may antedate subcutaneous emphysema by a number of hours these authors consider that early examination of the chest for evidence of air in the mediastinum or retrocardiac area is mandatory. In one of our patients the presence of Hamman's sign permitted the auscultatory diagnosis of mediastinal emphysema.

Chest findings are an invariable component although the type and the evolution of these vary from patient to patient. Among the commonest are dyspnea or orthopnea, and cyanosis. Pleural effusion, pneumothorax, hydropneumothorax, emphysema, or reactive pleuritis and pneumonitis are often found by physical or roentgenographic examinations. Both of these latter should be repeated often because of the rapidity with which the disease progresses. Compression of the mediastinum may lead to the development of the superior mediastinal syndrome as it did in the second patient of Lindemann.[84]

Among the rarer manifestations may be mentioned those described by Roy[123] and by Lindemann.[84] In the first the patient exhibited a remarkable condition. Propped up in bed, with each expiration there projected from his mouth for a distance of 3 or 4 feet a finely divided spray of a dark brown fluid of which there seemed an endless supply. Roy explained this by analogy with a throat spray. Assuming that the cardiac orifice was closed, the esophagus as far down as the perforation could act as the vertical tube of the throat spray, and the extravasated fluid in the posterior mediastinum could be gradually aspirated into the esophagus in a finely divided state mixed with the air that almost certainly would find its way into the pleural cavity. He further assumed that when this material reached the level of the larynx, the forcible expiratory movements of the lungs could act as the bellows of the throat spray and propel the particles to a distance.

In Lindemann's case there was a loud gurgling sound as when air is blown under a fluid. Moreover, on every rapid motion of the patient one could hear the characteristic bubbling. This continued for the 15 hours he survived.

CASE REPORTS

CASE 1 (Charity Hospital Unit No. Tul. 47-285742).—E. C., a 31-year-old Negro woman, was admitted to Charity Hospital at 1:00 P.M. on April 14, 1952, because of shaking chills and fever, vaginal bleeding, and pain in the abdomen. She was gravida iv; pregnant iv; aborta 0. The last menstrual period had been two months prior to the admission. One week prior to admission, she had had diarrheal stools, was nauseated, and vomited several times. There were two episodes of vaginal blood spotting at this time also. Two days prior to admission she had true rigors and fever. She noticed, then, a swelling of her lower

abdomen and sharp intermittent pains in this area. There was no radiation of pain. There were no fainting spells or other complaints. She had been treated five years previously in Charity Hospital for "infectious hepatitis."

Examination revealed an apprehensive, acutely ill Negro woman with blood pressure 100/80, respirations 22, and pulse 160. Temperature was 102° F. An indurated tender irregular mass was felt in the lower abdomen from the symphysis pubis up to 2 inches above the umbilicus on the left. There was no rigidity or rebound tenderness of the abdomen. Pelvic examination revealed the uterus to be displaced anteriorly by a hot, tender, fluctuant mass in the cul-de-sac, which also bulged into the rectum. The clinical impression was tube-ovarian cul-de-sac abscess. Roentgenogram of the chest and subdiaphragmatic area showed gas-capped small intestinal fluid levels, suggestive of ileus, but no subdiaphragmatic air.

A colpotomy was performed the day of admission, and 400 c.c. foul smelling pus was obtained, which cultured out escherichia, enterococcus, and microaerophilic, nonhemolytic, streptococcal organisms. Roentgenogram of the chest on April 15 showed elevation of the right leaf of the diaphragm, with air underneath the right diaphragm. Also, there was a compression atelectasis of the right lower lung and a hazy infiltration suggesting pneumonitis. The left lung was clear. Two days later, no air was seen under the diaphragm on x-ray examination, and both leaves of the diaphgram were symmetrically elevated. The patient became slightly irrational on the third hospital day and showed marked toxic signs despite broad spectrum antibiotics and intravenous fluids. She became questionably icteric at this time also. The clinical impression at this time was profound septicemia, with massive pericarditis, and acute heart failure. The patient was digitalized, but to no avail, and she expired at 7:00 A.M. on April 21. Her course was a septic one, with daily fever spikes to 104° F., and her temperature was at no time normal while in the hospital.

Post-mortem examination revealed acute ulceration of the left posterolateral aspect of the lower one-third of the esophagus with perforation into the left pleural cavity; incomplete abortion; perforation of the posterior wall of the uterus; multiple small pelvic abscesses; generalized peritonitis (fibrinous); atelectasis of the lower lobes of both lungs; and pericarditis (fibrinous).

CASE 2 (Charity Hospital Unit No. LSU 50-422789).—A. N., a 64-year-old white man, was admitted to Charity Hospital on June 25, 1950, and died one hour later. Two days before he had suddenly developed very severe low back pains (around the sacral region) which radiated to his anterior chest, and dyspnea. There was also a long history of hematuria and melena.

Examination revealed a blood pressure of 96/74, pulse 132, temperature 104° F. (rectal). The heart was not remarkable other than for tachycardia. The lungs were emphysematous and fine râles were noted in both lower lung fields. The abdomen was scaphoid, and the abdominal veins were seen to be prominent. A hard fecal mass was present on rectal examination. Urinalysis showed 1 plus albumin, and 1 plus sugar. The urine microscopic examination revealed many red cells (uncentrifuged).

Despite heroic supportive measures, the patient became cyanotic and hyperpyretic, and expired. Clinical impressions were renal calculus, bleeding peptic ulcer, possible coronary occlusion.

Autopsy revealed a ruptured esophageal ulcer, 1.5 cm. in diameter, on the posterior surface just above the esophagogastric junction. Sections of this revealed replacement of the mucosa by acute and chronic inflammatory cells. The muscularis was thickened and edematous and a marked inflammatory process was present. The serosa was markedly involved by an acute fibrinous exudate, clumps of bacteria, and polymorphonuclear cells. A mediastinitis, right pneumothorax, and right empyema were present, along with acute passive congestion of the liver. Chronic benign ulcer of the antrum of the stomach and chronic atrophic gastritis were noted (and these probably accounted for the history of melena). Chronic pyelonephritis and bilateral renal calculi were incidental findings at necropsy.

CASE 3 (Charity Hospital Unit No. Ind. 50-412322).—J. G., an 8-year-old white boy, was admitted to Charity Hospital on Sept. 9, 1950, and expired that same day. Three months

before he had had an appendectomy (for "acute suppurative appendix"). Two days before admission he began having continuous abdominal pains. Three hours before admission, with the abdominal pains continuing, the patient began vomiting, which became progressively more intense and frequent, and finally vomited coffee-groundlike material. Respirations became labored, and a shocklike state ensued.

Examination revealed a blood pressure of 80/50, pulse 110, respirations 20. Temperature was 101° F. Heart sounds were feeble and a tachycardia was present. The left chest was dull to percussion and no breath sounds were heard. The abdomen was distended and rigid. No peristalsis could be detected. X-ray examination of the chest showed hydropneumothorax on the left. Thoracentesis was performed and 250 c.c. greenish brown fluid and 4,200 c.c. air were removed from the left chest. A catheter was left in the left chest, with a water trap in place. There was a constant escape of air from the left chest, but the dyspnea was unrelieved. The patient died eight hours after admission. The clinical diagnoses entertained were acute surgical abdomen due to obstruction from adhesive band; ruptured peptic ulcer; ruptured spleen. Rupture of the esophagus was not considered.

The main autopsy findings were a gangrenous loop of small bowel (30 cm. in length) due to small adhesions in region of previous appendectomy between the colon and posterior peritoneum; rupture of the esophagus, 1.0 by 1.0 cm. longitudinal tear, in upper left lateral margin of the lower third portion; bilateral atelectasis of the lungs. Five hundred cubic centimeters of gray-green, fetid material was present in each pleural cavity. Sections of the ruptured esophagus showed only slight cellular infiltration along the site of the rupture. It was felt that the intestinal obstruction had caused the severe vomiting, which resulted in rupture of the esophagus.

CASE 4 (Charity Hospital Unit No. Tul. 53-97506).—D. M., a 2-month-old Negro boy, was admitted to Charity Hospital on March 23, 1953, with the chief complaint by his mother of "vomiting on feeding."

The child's mother related that he was taking three ounces of milk per feeding without difficulty until about two weeks prior to this hospitalization, when he began to vomit immediately after each bottle. The patient lost a total of two pounds of weight in this time, and it was then that the mother first noticed a "small round ball" in the epigastric area.

On examination, the patient appeared markedly dehydrated and undernourished. Temperature was 97.2° F., pulse 105, respirations 23. The abdomen was slightly protuberant but the liver, spleen, and kidneys were not palpable. A firm, nontender mass, measuring 2.5 by 1.0 cm. was felt in the right upper quadrant of the abdomen. The bowel sounds were hyperactive. Vomiting after a test bottle was considered both projectile and nonprojectile.

The child was hydrated with various fluids and electrolytes, and on the fifth hospital day, a pyloroplasty (Ramstedt procedure) was performed. On the first postoperative day, bloody froth was aspirated from the stomach. The Levin tube was passed with ease. Later in the day, March 29, the infant was found dead in the bed with regurgitated material by the pillow.

Laboratory findings on admission revealed hemoglobin 12 grams; 4.5 million red blood cells; 37 packed cell volume; 27 (uncorrected) erythrocyte sedimentation rate; 13,120 white blood cells; normal differential peripheral blood smear. Normal urinalysis.

Relevant autopsy findings included an 8 mm. longitudinal esophageal perforation located posteriorly at the esophagogastric junction. Clotted blood was present in the esophagus with the largest clot measuring 5 by 1 cm. located in the distal portion at the site of the rupture.

A bilateral hemothorax was present. Four cubic centimeters of serosanguinous gastric contents were noted in the right pleural space, and 2 c.c. of similar material in the left pleural space. The gastric contents had been aspirated. Pyloric stenosis was present, and there was acute gastric dilatation. Evidence of the Ramstedt procedure (postoperative status) was noted.

CASE 5 (Charity Hospital Unit No. Tul. 49-384988).—S. T., a 3-year-old Negro girl was admitted to the Contagion Unit of Charity Hospital on May 6, 1953, in a semicomatose

condition. She had history of a sudden onset of jaundice, anorexia, vomiting, and abdominal pain, associated with light stools and dark urine, approximately twelve days prior to admission to Charity Hospital. Vomiting became more frequent and, one day prior to hospitalization, she convulsed.

On examination, one saw a comatose child with intense scleral icterus. The diaper was stained a bright golden yellow. The temperature was normal. The liver was palpated one fingerbreadth below the costal margin. Flaccid paralysis was generalized, and there was no abdominal reflex. The pupils were round, but the left was dilated slightly more than the right.

Laboratory findings included a negative spinal survey, negative peripheral blood agglutinations, normal peripheral hemogram, stool negative for ova, cysts, or parasites, and a positive urine urobilin (dilution not recorded).

Despite vigorous measures, the patient expired the day after admission (May 7).

At autopsy, the relevant findings were perforation of the left lateral lower third of the esophagus with spillage of gastric contents into the left pleural cavity; an annular (congenital) pancreas; a liver which was compatible with fulminating hepatitis with jaundice.

CASE 6 (Charity Hospital Unit No. LSU 42-21609).—L. M., a 38-year-old Negro woman, had had bronchial asthma for fourteen years, attributed to sundry foods and inhalants. Her course was reasonably smooth under allergic management, although she had been hospitalized several times in status asthmaticus. Her terminal illness began March 29, 1952, while in Charity Hospital, which she had entered for study of menorrhagia.

While on the Gynecology Service, symptoms of bronchial asthma associated with retching and vomiting started. She was given aminophyllin intravenously with noteworthy benefit. She was discharged on April 1, 1952, though somewhat weak and dyspneic. This was premature, for it was necessary to readmit her the next day. Relevant findings on physical examination of this undernourished, emaciated, severely ill woman were those of fever (to 100° F.), exhaustion, and status asthmaticus. She again responded well to aminophyllin by vein. The trachea was aspirated with removal of much thick mucoid sputum. A tracheotomy was done. Penicillin (400,000 units) was given every four hours; 100 mg. of cortisone was given every two hours. The next morning (April 3) she was lying quietly in bed; the initial dehydration and exhaustion were improved. That afternoon, her breathing became loud and of the Biot type, her heart rate was 180 to 190 per minute, and she developed nystagmus. Large amounts of thick, pink mucus were aspirated from the tracheotomy tube. She was digitalized with Cedilanid because of impending heart failure. Within a few hours the heart rate decreased to 120 per minute, the breathing was much improved, and the nystagmus had disappeared. She vomited and retched from time to time.

On April 4 she had icy cold extremities in spite of a fever ranging between 102° and 105° F. At this time her asthma was no longer a problem. She was given 1,000 c.c. of blood. On April 5 the blood pressure was 120/60 and the pulse rate was 92 per minute. Streptomycin was added. A crunching sound, which began with the first heart sound and lasted throughout systole, was heard and considered extracardiac by a staff physician. An electrocardiogram, as before, was suggestive of chronic pulmonary disease. Her general condition was much improved and she became afebrile. She remained afebrile until April 7 when her temperature rose to 102° F. and the pericardial crunch disappeared. She died at 12:30 A.M., April 9. During the entire period in the hospital, her sensorium was clouded, and much of the time she was unresponsive to pain.

At autopsy, the main findings were myocardial infarction with mural thrombosis, and multiple infarcts of the spleen, kidneys, and brain; bronchial asthma, chronic passive congestion of the lungs and liver, and rupture of the esophagus on the anterior surface of its lower third, with mediastinitis.

Section of the esophagus in the area of perforation showed complete digestion of the mucosa and submucosa, and partial digestion and necrosis of the muscularis intima. The rupture was 3 cm. above the cardia, and 3 by 2 cm. in diameter.

Sections of the brain cortex showed focal areas of hemorrhage throughout. Some of them were quite small. Very little gliosis was noted around them. A few small thrombi were seen in the cerebral arteries. Section of the cerebellum showed no significant lesions.

CASE 7 (United States Armed Forces Institute of Pathology Protocol No. 76606*).—C. B., a 51-year-old alcoholic white man returned to camp after a heavy drinking debauch of twenty-four hours' duration. The patient was unable to give antecedent details. He went into shock, became cyanotic, and rapidly developed subcutaneous emphysema from chin to knees. Two chest films were read as showing "nothing definite." A small, superficial, lacerated wound was present in the right upper quadrant of the abdomen. Efforts to control shock were unsuccessful, and he died six hours after the acute onset.

At autopsy the relevant findings included extensive subcutaneous emphysema of the face, neck, and chest in a well-developed and nourished man. The abdomen was distended and tympanitic. There were 800 mg. of seropurulent fluid in each hemithorax. The mediastinum was not enlarged. The posterior surfaces of the esophagus and aorta were thick, edematous, dark grayish-yellow, and infiltrated with blood. There was a 1.5 cm. long perforation of the esophagus located 1.5 cm. above the diaphragm. The tissues of the posterior mediastinum were infiltrated with blood. The mucosa of the stomach was normal.

Microscopically, there was seen a small superficial ulcer of the esophagus. An exudate extended through all layers of the esophagus and was continuous with a similar exudate in the periesophageal connective tissue. Several small submucosal veins were distended and thrombosed. Numerous necrotic areas were seen, periesophageally.

Pathologic diagnoses: perforation of the esophagus, lower one-third, cause undetermined; acute suppurative mediastinitis; severe bronchopneumonia, all lobes; multiple lung abscesses; intense subcutaneous emphysema and bilateral fibrinopurulent pleuritis.

CASE 8 (United States Armed Forces Institute of Pathology Protocol No. 567170).—G. G., a 72-year-old white man, had had stomach trouble for ten years, diagnosed as peptic ulcer. Three weeks prior to admission he had abandoned his bland diet; right upper quadrant pain and vomiting appeared two weeks later; and he was hospitalized. Examination disclosed a chronically ill, but well-developed and nourished, man. Excursions of the chest were limited, the liver was somewhat enlarged and there was tenderness over the epigastrium. Significant laboratory findings included fecal occult blood and chronic bronchitis by roentgenogram. He was placed on conservative ulcer regimen, but he vomited several times every morning. Ten days after admission he had a severe epigastric pain accompanied by increasing vomiting. He went into shock. Although he continued to complain of severe pain in the abdomen, no rigidity was present. Roentgenologic examination showed a left hydropneumothorax, with the chest two-thirds full of fluid. It was thought that he had ruptured either his esophagus, or a hiatus hernia. Despite supportive treatment the shock became worse. A large trocar was inserted into the left pleural cavity and continuous drainage was applied. He died twenty-four hours after the acute onset.

At autopsy the left pleural cavity contained 2,000 mg. of brown turbid fluid, with food remnants in it. The left lung occupied one-fourth of the pleural space, weighed 400 Gm. and was chamoislike, dark red, and cyanotic on cut surfaces. The left pleural surfaces were dirty brownish-gray throughout. The right lung was normal in appearance and weighed 530 Gm.; the right pleural space contained 500 mg. of turbid, dark amber, odorless fluid.

The esophagus was hyperemic in its upper two-thirds and was slightly edematous. Lower, the wall was very soft and 2.5 cm. above the cardia was transformed into a brownish tender mass which tore at the slightest touch. There was a left-sided tear. The tissue around the lower portion of the esophagus was dark green; at one point on the left side above the cardia this green tissue touched directly the mucosa of the esophagus, indicating a pre-existing perforation. No defects were found in the gastric mucosa.

The microscopic examination confirmed the severe left pleuritis and atelectasis. The tissues of the lower portion of the esophagus were intensely hyperemic, hemorrhagic, and widely necrotic with much epithelium missing. There was a purulent periesophagitis.

The pathologist concluded that this was a case of spontaneous rupture of the esophagus.

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*The cases from the Armed Forces Institute of Pathology are published through the kind permission of Brig. Gen. Elbert DeCoursey, Director, and through the courtesy of Major Purvis, who afforded us every facility to study the vast resources of the Institute at first hand.

CASE 9 (United States Armed Forces Institute of Pathology Protocol No. 77803).—A 31-year-old white man, F. S., was admitted with a severe knifelike pain in the epigastrium while vomiting due to excess of alcohol. He was in extreme pain, shouting and moaning. He was lying on his side with the knees flexed. There was generalized cyanosis and breathing was rapid, shallow, and difficult. The pulse was 136 and the temperature 99.4° F. The skin was cold and clammy. There was generalized abdominal rigidity much increased over the epigastrium, where intense pain and tenderness were present. The lower abdominal quadrants were not tender and the lower abdominal muscles relaxed with respiration.

The pain, starting in the epigastrium but radiating to the chest, came on suddenly after nausea and vomiting. The patient was observed in a large country hospital for five hours and transferred to an Army hospital where a negative exploratory laparotomy was done. His pains were never controlled by morphine sulfate; the air hunger continued. Subcutaneous emphysema was detected in the face, neck, and upper chest extending 2 inches below the level of the nipples. Roentgenogram of the chest showed subcutaneous emphysema throughout the neck and thorax and edema of both lungs. He died twenty-four hours after hospitalization.

At autopsy the relevant findings included subcutaneous emphysema from the face to the upper portion of the thighs. The left lung was collapsed away from the chest wall; the left pleural space contained 200 mg. of brownish-yellow turbid fluid. The right lung was normally expanded; the right pleural space contained 300 mg. of the same fluid. A fibrinous exudate covered much of the surface of both lungs. Multiple fine, fibrous adhesions were present between the visceral and parietal pleura of the lower one-half of the left lung and the diaphragm. On separation of these adhesions there was found pus, undigested food, and other gastric contents. There was a fibrinous exudate on the epicardium. The posterior mediastinum contained a large amount of purulent exudate. There was an acute perforation of the posterolateral wall of the œsophagus just above the diaphragm large enough to permit the entry of the finger. There was a second small ulceration on the posterior surface distinct from the point of rupture. There were also several longitudinal fissures of the mucosa in this region. The mucosa of the stomach was intact throughout.

Microscopically, there was an acute inflammatory reaction in the serosa of the esophagus; the mucosa was desquamated and only small bits were present. There was very little inflammatory reaction in the remaining fragments.

Pathologic diagnoses: acute perforation of the esophagus; massive collapse of the left lung; right pyothorax; multiple early small lung infarcts; acute suppurative mediastinitis; acute pericarditis.

CASE 10 (United States Armed Forces Institute of Pathology Protocol No. 120811).—J. C., a 20-year-old white man, was admitted to the hospital because of excruciating pains in the right kidney region. Nausea and vomiting, and desire to urinate, followed. A nephrostomy was performed. If he only took a sip of water, it provoked vomiting of dark bloody frothy material. Cyanosis and cold clammy skin developed. He died the next evening. Crepitus of the tissues of the neck was noted just prior to death.

At necrospy significant findings included a distended and tympanitic abdomen. The lungs were moderately collapsed, filling about one-half the thoracic cavity. On the left there were 200 mg. of greenish-brown opaque fluid. Pressure on the stomach caused expulsion of this fluid, with gas, into the left hemithorax. On the left posterior wall of the esophagus there was a longitudinal rent 2.5 cm. long, 1.5 cm. above the diaphragm. The edges of the tear were lacerated but the area adjacent was smooth, flexible, and only slightly discolored. There was considerable necrosis of mediastinal tissues.

Very many (75) sections of the esophagus were examined microscopically. There was extensive necrosis of the serous layer and the outermost muscle coat; denudation of the mucosa was found throughout. The rupture occurred in the region of the muscularis mucosae and extended longitudinally in this area. No changes in the muscles gave any reason for the

rupture. A papilloma of the esophageal wall was present but did not appear to have offered resistance to the passage of foods or liquids. The pathologist thought it may have contributed to an abnormal intraesophageal pressure leading to rupture.

Pathologic diagnoses: spontaneous rupture of the esophagus; hydropneumothorax; posterior mediastinitis with necrosis, severe; acute suppurative pyelonephritis; right hydronephrosis; hypoplasia of left kidney.

CASE 11 (United States Armed Forces Institute of Pathology Protocol No. 275991).—P. N., a 53-year-old white man, suddenly developed epigastric and chest pain and collapsed following his evening meal. He died nine hours later. No further details of his illness were available.

Fig. 18.—Photomicrograph from section of esophagus of Case 11. (Picture 54-2779 Acc. 275991)

At autopsy 2,000 mg. of brownish-yellow fluid containing fat droplets were found in each pleural cavity. The organs of the chest were separated posteriorly by a large amount of grayish-green, necrotic, semifluid, semiloculated material surrounding the hilar regions of both lungs, the trachea, esophagus, and aorta. There was much air in the mediastinum. The mucosa of the esophagus was hyperemic and streaked with whitish linear markings running its entire length. An ulceration was present just above the cardia on the posterior wall of the esophagus, measuring 1 by 2 cm., and extending through the wall into periesophageal tissue. The stomach contained one liter of the same material found in the pleural spaces.

Fig. 19.

Fig. 20.

Fig. 19.—Photomicrograph from section of esophagus of Case 11. (Picture 54-2781 Acc. 275991.)
Fig. 20.—Photomicrograph from section of esophagus of Case 11. (Picture 54-2782 Acc. 275991.) (Figs. 18, 19, and 20 are from the Armed Forces Institute of Pathology. They are reproduced by permission of Brig. Gen. Elbert DeCoursey, Director, and through the courtesy of Major William E. Purvis, III.)

Just proximal to the pyloric sphincter was a well-healed ulcer on the lesser curvature. Microscopically, the mucosa of the esophagus was seen to be interrupted at several points by acute ulceration. In the adventitial areas there were undigested food particles, debris, and masses of microorganisms. Many muscle fibers showed degenerative, necrotic reaction extended throughout the entire esophageal wall.

Pathologic diagnoses: pulmonary and subcutaneous emphysema; rupture of the esophagus; acute esophagitis; pulmonary atelectasis; old peptic ulcer of stomach, healed.

CASE 12 (United States Armed Forces Institute of Pathology Protocol No. 4377).—J. D., a 3½-year-old white boy, was given castor oil for obstipation. He vomited 6 to 8 times after this, following which there was sustained opisthotonus with pain on flexion of the legs. Lumbar puncture was negative. There was projectile vomiting, Kussmaul breathing, and dehydration leading to coma. He barely responded to painful stimuli. He rapidly went downhill and died.

In the left pleural cavity 150 mg. of brownish-black fluid was found oozing from a large rent in the distal 5 cm. of the esophagus. There was a marked chemical pleuritis. The stomach showed four large areas of ulceration, and complete perforation, apparently ante mortem.

Pathologic diagnoses: acute perforation of the esophagus, cause undetermined; acute left chemical pleuritis; acute bronchopneumonia; mild chemical peritonitis; severe acute parenchymatous liver degeneration.

CASE 13 (United States Armed Forces Institute of Pathology Protocol No. 526990).—T. W., a 17-month-old boy, vomited three times on the day of admission. Slight nuchal rigidity appeared and dyspnea developed. Cheyne-Stokes respiration followed and preceded death, which took place forty minutes after hospitalization.

Significant findings at necropsy included 400 mg. of bloody fluid, containing food particles, in the left pleural space. A longitudinal laceration, 1 cm. in length, was present on the left lateral wall of the distal esophagus. The tissues were soft and hemorrhagic about this defect. *Escherichia coli* were isolated from the brain and were considered the cause of the fulminant meningitis.

Pathologic diagnoses: rupture of the esophagus; hydropneumothorax; purulent meningitis; Waterhouse-Friderichsen syndrome.

CASE 14 (United States Armed Forces Institute of Pathology Protocol No. 313978).—W. W., a 56-year-old Negro man, was admitted with chief complaints of right-sided chest pain and fever of approximately one week's duration. The onset followed lifting heavy trash cans. Chest pain was never absent thereafter, and at times was intense. A nonproductive cough made its appearance as well as night sweats.

He appeared actuely ill and dehydrated. There was limitation of chest expansion bilaterally, especially on the right. The percussion note was dull on the right side below the second intercostal space anteriorly and the midscapula posteriorly. Breath sounds were absent over the corresponding areas. The left hemithorax was hyperresonant and a friction rub was heard at the right base anteriorly. The heart was shifted to the left.

Roentgenogram of the chest showed a dense homogeneous shadow over the entire right side with obliteration of the diaphragm and bulging of the lower ribs. The heart and mediastinum were displaced to the left. A right thoracentesis was done the day after admission and 1,300 mg. of foul, gray-green pus removed. Closed drainage was instituted and a large amount of purulent material removed. An esophagopleural fistula was detected when he swallowed methylene blue and it appeared in the pleural aspirate. This was considered due to spontaneous rupture of the esophagus at the onset of his disease, seven days prior to admission. Because the closed chest drainage was unsatisfactory, open drainage was attempted. His temperature remained at elevated levels and he died two days after admission.

At autopsy the lungs did not collapse when the pleural cavity was entered. A large empyema cavity was found on the right. A sinus tract 5 cm. above this space was found, entering the esophagus 3 cm. above the diaphragm. At the site of the esophageal rupture there was no evidence of malignancy, acute or chronic infection, stricture, varix, or trauma.

On microscopic examination, the junction of the esophagopleural fistula showed a thinned and desquamated mucosa. The wall of the fistula was composed of dense fibrous tissue with many budding capillaries. Many lymphocytes, fibroblasts, polymorphonuclear leukocytes, and large fixed macrophages infiltrated into the wall of the sinus tract. The gastric mucosa was desquamated but otherwise normal.

Pathological diagnoses: rupture of the esophagus; right esophagopleural fistula; right empyema and atelectasis.

ROENTGENOLOGIC ASPECTS

Since the radiologic findings can be either suggestive or pathognomonic of rupture of the esophagus, it is essential that at least an erect posteroanterior chest film, including the immediate subdiaphragmatic region, should be taken in all instances in which the diagnosis is suspected. Roentgenologic examination of the chest is the single most valuable laboratory test, and the findings are helpful in confirming the pneumothorax and pleural effusion, if present, especially when the physical examination is unsatisfactory. The lung fields should be carefully scrutinized, looking for fluid, mediastinal widening, pneumonia (unilateral or bilateral), emphysema, fluid, and/or air in the mediastinum.

An early hydropneumothorax, usually caused by the irritant action of gastric contents on the mediastinal surfaces of both pleurae, will cause delayed appearance or absence of subcutaneous emphysema. The absence of mediastinal or subcutaneous emphysema points to a direct perforation into the free pleural space. Hence, hydropneumothorax indicates pleural perforation.

Pneumothorax without demonstrable fluid or with slow accumulation of fluid is so infrequently seen with rupture of the esophagus that its presence is suggestive of spontaneous pneumothorax or spontaneous mediastinal emphysema with secondary pneumothorax.[43]

The presence of air in the tissues, usually around the base of the neck, can be detected on a roentgenogram and is an early sign of surgical emphysema. The accumulation of air in the mediastinum courses upward, along fascial planes, under pressure; it dissects from the crura of the diaphragm into the superior mediastinum and thence into the root of the neck, and the subcutaneous tissues.[32] Air may be palpable in the neck from one[88] to twelve hours[86] after the rupture of the esophagus. It should be mentioned here that mediastinal emphysema may also be seen in rupture of the uterus or of a gastric or duodenal ulcer. Only 70 to 80 per cent of proved cases of ruptured duodenal or gastric ulcer will show subdiaphragmatic air. Therefore, in a case of mediastinal emphysema, the absence of subphrenic air rules out ruptured ulcer.[43] Subdiaphragmatic air has never been reported in spontaneous rupture of the esophagus. Air behind the heart in conjunction with mediastinal emphysema is said[86] to be diagnostic of rupture of the esophagus.

The presence of a massive, rapidly increasing hydropneumothorax strongly suggests spontaneous rupture of the esophagus.[104]

Demonstration of an esophageal fistula is extremely important. This is done, preferably, with Lipiodol[114] and, if positive, demonstrates the site and extent of the fistula. The presence of a small amount of Lipiodol in the extravasated area in the mediastinum or pleural spaces is no disadvantage and can act as a guide to the surgeon, especially in small esophageal defects. Kinsella, Morse, and Hertzog[77] feel that it is very important, diagnostically speaking, for the patient to be in the proper (upright) position for barium or Lipiodol swallow. Osler Abbott[1] further states that satisfactory bedside studies can be done on comatose or moribund patients by intraesophageal instillation of a contrast medium through a Levin tube. Barium studies of the esophagus may aid in specific cases, but several films with different degrees of filling are usually necessary to detect small lesions in the mucosal surface. Also, the rapidity of barium passage in the esophagus may be such as to cause the examiner to fail to detect a small lesion, including small superficial ulceration associated with a diaphragmatic hernia or actual peptic ulceration without careful fluoroscopic study, and films *ad seriatim*.[136]

Roentgenographic Findings in Spontaneous Rupture of the Esophagus in 52 Cases (expanded from Priviteri and Gay[114]):

Negative posteroanterior chest examination	3
Hydro(pneumo)thorax, left	
With emphysema, cervical or mediastinal	18
Without other findings	11
Hydro(pneumo)thorax, right	
With emphysema, cervical or mediastinal	2
Without other findings	3
Hydro(pneumo)thorax, bilateral	
With emphysema, cervical or mediastinal	5
Without other findings	1
Emphysema, cervical and/or mediastinal only	7
Tension pneumothorax	1
Chest films unsatisfactory	1

The most common roentgenographic findings in rupture of the esophagus are hydrothorax, hydropneumothorax, mediastinal and neck emphysema, and esophageal fistula.[114] Roentgenographic confirmation of spontaneous rupture of the esophagus, in all suspected cases, is a sine qua non.

DIAGNOSIS

Knowledge of the foregoing usually permits a prompt diagnosis; indeed the diagnosis has been made over the telephone, or at a glance. When the salient features of rigidity of the upper abdomen, dyspnea and subcutaneous emphysema are lacking, and when the condition has not been precipitated by violent retching or vomiting, then confusion with other entities may arise. The mistaken diagnosis of perforated peptic ulcer is commonly made, especially by surgeons. The internist more generally incorrectly ascribes the disease to acute occlusion of a coronary artery. Other states having points in common with rupture of the esophagus include acute pancreatitis, empyema of the gall bladder, spontaneous pneumothorax, acute poisoning, pulmonary embolism, rupture of the diaphragm, incarceration of a diaphragmatic hernia, renal colic, fulminating

coccal infections of the kidney, acute cholecystitis, mesenteric thrombosis, splenic infaret, rupture of a subphrenic or hepatic abscess, and interstitial emphysema.

The diagnosis of rupture of the esophagus is established by demonstrating the communication with the pleural cavity. A soft rubber catheter may be guided through the rent under fluoroscopic visualization or a small amount of methylene blue taken by mouth may be recovered in the pleural aspirate. The aspirate should be tested for hydrochloric acid and studied for food particles microscopically. Lipiodol may demonstrate the lesion nicely roentgenographically. Palmer[106] visualized the defect by esophagoscopy.

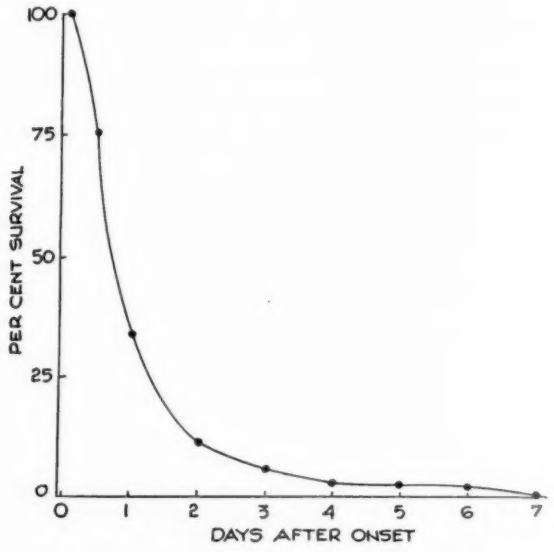

Fig. 21.—Survival time in 71 untreated cases.

PROGNOSIS

The extremely malign nature of the condition is emphasized in Fig. 21 which depicts the very short survival time of untreated patients. Only 35 per cent (24 of 71) survived twenty-four hours; 11 per cent lived to the end of the second day, and none lived longer than one week.

The hazards of intellectual torpidity in diagnosis, or of delaying surgery after the diagnosis has been made are underscored by the death of 25 per cent of patients within twelve hours after the accident.

By contrast, modern developments in chest surgery permit the cure of a large number of these ruptures. Such relatively simple procedures as thoracentesis or thoracotomy may prolong or even save lives; ideal results follow repair of the rent in the esophagus and cleansing of the thorax.

TREATMENT

Treatment consists essentially of immediate surgical repair of the rent via thoracotomy, satisfactory drainage of the mediastinal and pleural spaces, and supportive adjuvant therapy. Shock is not considered a contraindication to

surgery. Thus Scholefield's[127] second patient, a 63-year-old woman, made a complete recovery though she was in extremis at the time of operation. The mediastinal pleura is incised throughout its entire length in order to decompress the mediastinum. This generally leads to immediate improvement. Free drainage into the pleural cavity is thus established, and this is, in turn, drained off by means of a tube anchored in place in the left chest, connected to a water-sealed bottle. The importance of immediate decompression of high intrapleural and mediastinal pressures is to be stressed. Samson[125] categorically states that "conservative" drainage procedures have no place in the early hours after rupture of the esophagus. He further feels that the surgical premises used in the modern treatment of wounds of a hollow viscus, such as prompt resuscitation, exploratory operation, and closure of the defects, should be followed in spontaneous rupture of the esophagus, even though this organ is in the chest.

If a victim of this catastrophe survives for twenty-four hours, it is felt that pleural space drainage may succeed. For survivals without surgery until infection has been established, drainage procedures are helpful; but, for drainage during the stage of contamination it is considered useless for preserving life.[125]

Ware and Strieder[143] have found that there is no difference in the survival time of control untreated animals compared with those given supportive therapy (such as parenteral fluids, sulfadiazine, and penicillin). The animals with the same supportive therapy but a delayed surgical repair survived longer than the first two groups. Most of those given supportive therapy and benefit of immediate surgical repair survived.

Postoperative complications mentioned by Anderson[3] include empyema, mediastinitis, and breakdown of the repair. He emphasizes adequate use of antibiotics.

Treatment consists of the following procedures: (1) Resuscitation measures, as needed; (2) Thoracentesis, which alone may increase the duration of life, if immediate thoracotomy is not feasible; (3) Discontinuation of all material by mouth. A Levin tube should be inserted into the stomach, and kept under continuous suction. Parenteral alimentation; (4) Adequate antibiotic therapy, as indicated; (5) Nasal oxygen; (6) Thoracotomy, with resection of the seventh or eighth rib, then opening of the pleural cavity, and/or mediastinal cavity, establishing adequate drainage. Exposure and repair of the esophagus, by layers where possible; (7) Thorough débridement of the mediastinum, and adequate warm saline lavage of the open mediastinum and pleural cavity; and (8) Re-expansion of the lung, on the affected side, as soon after surgery as possible. Bronchoscopy may be needed.

Reference to Chart 1 will show that there have been 55 patients operated upon to date. Of these, 35 have survived, a mortality rate of 36 per cent.

Even with the recent splendid developments in thoracic surgery, the prediction of Walker[141] that "the mortality will always be high," regrettably, is still accurate.

CHART I. OPERATIONS REPORTED THROUGH 1952

AUTHORITY	OPERATION	POSTOPERATIVE COMPLICATIONS	RESULTS
Abbott, O. A. 1950	Left thoracotomy and surgical repair of esophagus	Esophageal fistula, empyema	Dead; nine months
Allison, P. 1950	Left thoracotomy and surgical repair of esophagus	Esophageal fistula, empyema	Cured
Alt, Bixby and Rowell No. 1 1953	Left thoracotomy and surgical repair of esophagus	Dissolution of the suture line in the esophagus, extensive mediastinitis	Dead; 8 days
Alt, Bixby and Rowell No. 2 1953	Left thoracotomy and surgical repair of esophagus	None	Cured (Patient has carcinoma of the stomach)
Anderson No. 1 1952	Left thoracotomy and surgical repair of esophagus	"Stormy convalescence"	Cured
Anderson No. 2 1952	Thoracentesis; left thoracotomy and surgical repair of esophagus	None	Cured
Anderson No. 3 1952	Decortication of lung; left thoracotomy and surgical repair of esophagus	Esophagopleurocutaneous fistula	Cured
Anderson No. 4 1952	Right thoracotomy and surgical repair of esophagus, gastrostomy	Esophagopleurocutaneous fistula	Cured
Barrett No. 2 1947	Left thoracotomy and surgical repair of esophagus, enterostomy	Esophageal fistula, mediastinal abscess, pulmonary abscess	Cured
Barrett No. 3 1950	Left thoracotomy and surgical repair of esophagus	Esophageal fistula, empyema	Cured
Beal 1949	Left thoracotomy and intercostal drainage	Empyema; mediastinitis; esophageal fistula; pericarditis	Dead; thirteen days
Bugden 1952	Left thoracotomy and surgical repair of esophagus	None	Cured
Carter, Alrich and Drash No. 1 1951	Left thoracotomy and surgical repair of esophagus	Empyema	Cured
Carter, Alrich and Drash No. 2 1951	Left thoracotomy and surgical repair of esophagus, decortication	Periesophageal abscess, sepsis	Cured
Cleland 1946	Intercostal drainage, pleura	Shock, empyema	Dead; twenty-four hours
Cliffton No. 1 1949	Left thoracotomy and surgical repair of esophagus	Pleuritis, bilateral thrombophlebitis lower extremities	Cured
Cliffton No. 2 1949	Thoracentesis	Cardiovascular collapse; sepsis	Dead; two and one-half hours

CHART I—CONT'D

AUTHORITY	OPERATION	POSTOPERATIVE COMPLICATIONS	RESULTS
Collis, Humphreys and Bond 1944	Left thoracotomy and surgical repair of esophagus	Shock	Dead; thirty hours
Dunavant and Skinner 1951	Left thoracotomy and intercostal drainage pleura	None	Cured
Foggitt 1946	Laparotomy and surgical repair of esophagus	Mediastinitis	Dead; thirty-six hours p.o.
Frink 1947	Closed intercostal drainage. Open drainage of empyema	Esophageal fistula, empyema	Cured
Gardner 1949	Drainage, posterior mediastinum	Esophageal fistula, mediastinal abscess	Cured
Graham No. 1 1944	Rib resection, empyema	Esophageal fistula	Cured
Graham No. 2 1944	Rib resection, empyema	Esophageal fistula	Cured
Guilmoto 1936	Left thoracotomy, gastrostomy	Suppurative pneumonitis	Dead; eighteen days
Higginson and Clagett 1948	Exploration mediastinum, and drainage	Bilateral empyema, mediastinitis	Dead; forty hours
Kernan 1950	Drainage superior mediastinum	Mediastinitis	Dead; seventeen hours
Kinsella No. 3 1948	Intercostal drainage pleura	Shock, empyema	Dead; three days
Kinsella No. 5 1948	Left thoracotomy and surgical repair of esophagus	Pulmonary embolus, 9th day	Dead; nine days
Kuttner 1918	Left thoracotomy and surgical repair of esophagus, gastric "feeding fistula"	Not given	Dead (time not given)
Lowenthal No. 1 1951	Left thoracotomy, and left pleural drainage	Not given	Dead; twenty-four hours
Lowenthal No. 2 1951	Left thoracotomy and surgical repair of esophagus	Coma, shock	Dead; four days
Lynch No. 1 1949	Intercostal drainage, pleura, drainage empyema, close fistula × 4, jejunostomy	Esophageal fistula, empyema	Cured
Lynch No. 2 1949	Left thoracotomy and surgical repair of esophagus	Esophageal fistula, empyema	Cured
Lynch No. 3 1949	Left thoracotomy and surgical repair of esophagus	None	Cured
Markowich and Svetoza 1932	Left thoracotomy, gastrostomy	None	Cured

CHART I—CONT'D

AUTHORITY	OPERATION	POSTOPERATIVE COMPLICATIONS	RESULTS
Mackler No. 1 1952	Left thoracotomy and surgical repair of esophagus	None	Cured
Mackler No. 2 1952	Left thoracotomy and surgical repair of esophagus	Sepsis	Cured
Mackler No. 3 1952	Left thoracotomy and surgical repair of esophagus	Cardiovascular collapse	Dead; eleven hours
Moore and Murphy 1948	Rib resection, empyema, jejunostomy esophagogastroplasty	Esophageal fistula, empyema	Cured
Olsen and Clagett 1947	Left thoracotomy and surgical repair of esophagus	Superficial wound infection	Cured
Overholt 1943	Left posterior mediastinotomy, bilateral pleural drains	Esophageal fistula, empyema	Cured
Plaut, A. 1952	Left thoracotomy and intercostal drainage	Coma, shock	Dead; eleven days
Samson No. 1 1951	Left thoracotomy and surgical repair of esophagus	None	Cured
Samson No. 2 1951	Left thoracotomy and surgical repair of the esophagus	Patchy atelectasis, severe penicillin reaction	Cured
Scholefield 1949	Left thoracotomy and surgical repair of esophagus	Esophageal fistula, empyema, wound infection	Cured
Selman 1952	Left thoracotomy and surgical repair of esophagus	None	Cured
Sencert 1911	Laparotomy and surgical repair of esophagus	Empyema	Cured
Slesser No. 1 1951	Left thoracotomy and surgical repair of esophagus	None	Cured
Slesser No. 4 1951	Left thoracotomy and surgical repair of esophagus	Empyema, with "stormy" convalescence	Cured
Slesser No. 5 1951	Left thoracotomy and surgical repair of esophagus	Esophagus reopened and was resutured (sutures did not hold); jejunostomy; peritonitis	Dead; sixteen days
Soupault and Couinaud 1952	Right thoracotomy and surgical repair of esophagus	Massive bronchopneumonia; pulmonary infarction	Dead; four days
Vestal 1950	Drainage empyema	Esophageal fistula, empyema	Cured
Walker 1914	Cholecystectomy, left thoracotomy, pancreatic drain, gastrostomy	Empyema	Dead; one hundred seventy-two hours
Ware, Shnider and Davis 1952	Left thoracotomy and surgical repair of esophagus	Patchy atelectasis	Cured

SUMMARY

The first case of rupture of the esophagus was described by Boerhaave[13] in 1724; the first antemortem diagnosis was reported by Meyer[98] in 1858; the first operative repair in this country was performed by Overholt[105] in 1943.

Pre-existing esophagitis or stricture may predispose to rupture, but the accident can take place in the entirely healthy esophagus. Almost all of these tears have been in the distal portion and have been longitudinal; two ruptures have been transverse. Rupture permits the gastric contents to enter the mediastinum; mediastinal emphysema, which may exteriorize in the neck, follows. The mediastinal pleura may rupture, producing pleural effusion, or hydropneumothorax, perhaps with pulmonary collapse. These changes produce the clinical symptoms; additionally, infection and shock contribute to the semeiology.

Because the esophagus had not previously been ruptured experimentally in situ this was done on 10 corpses, as soon after death and with as little disturbance of the normal anatomy as possible. Compressed air was employed for the purpose, and a Marsh Distiller Discharge Gauge used. After the rupture both pleural coverings were carefully searched for tears and any pleural fluid present was noted. The esophagus was observed, in situ, with careful attention being paid to the length and location of ruptures obtained. For comparative purposes esophagi of calves, adult cattle, and hogs also were ruptured. These were first removed from the bodies of the animals. As a control experiment, in order to obtain material of a uniform size and test strength, rubber condoms were also burst under varying times and pressures.

A mathematical analysis was prepared using the principles of free body diagrams. From this, it is concluded that hydrodynamic forces compel longitudinal tearing.

Most instances occur in middle life and old ages; five-sixths of 157 cases were in men. The onset is sudden, typically after vomiting, with violent pain in the epigastrium or precordium. There may be a sensation of something having torn or given way. Certain postures lessen the pain; breathing, swallowing, or movement of the body worsen it. Tenderness or rigidity of the abdominal wall may be associated. Thirst may be outstanding. Several writers have noted alteration of the quality of the voice. The appearance of subcutaneous emphysema is particularly characteristic, ordinarily first observed in the neck, although it may be completely absent. Chest findings are an invariable component but the type and evolution of these vary from patient to patient. Dyspnea and cyanosis are common. Pleural effusion, pneumothorax, hydropneumothorax, emphysema or reactive pleuritis, or pneumonitis are often found by physical or roentgenographic examinations. Both of these latter should be repeated often because of the rapidity with which the disease progresses.

The condition may be readily diagnosed; common mistakes in diagnoses are ruptured peptic ulcer or coronary occlusion. The diagnosis is established by demonstrating the communication with the pleural cavity. A soft rubber catheter may be guided through the rent with fluoroscopic assistance. Methylene blue by mouth may be aspirated, or Lipiodol or barium visualized.

The accident has an extremely malign prognosis; if surgery is not performed all patients die promptly. Only 35 per cent of 71 patients survived twenty-four hours; 11 per cent lived to the end of the second day, and none lived longer than one week. Treatment consists of immediate surgical repair via thoracotomy, drainage of the mediastinal and pleural spaces, and supportive therapy. Shock is not a contraindication to surgery. Fifty-five patients have been operated on to date; of these 35 have survived.

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Editorial

Problems and Obligations in the Treatment of Cancer

ALTHOUGH cancer does not rank first among the various diseases as a cause of death, being second to heart disease, it is nevertheless the cause of more confusion and misunderstanding than any other disease. Part of this confusion appears to arise from the fact that the vagaries and inconsistencies of cancer are so profound. This unfortunate circumstance makes it necessary for us to continue our attack against the disease with the very best scientific and philosophical means.

The ultimate result in cancer, as expressed in five- and ten-year survival, has improved during the past few decades, but during the past few years we cannot claim much improvement, and perhaps cannot expect much in the immediate future unless better methods of therapy are discovered. Part of the improvement during the past few decades has been due to more radical operative procedures for the disease. We can expect very little advance in the future from this standpoint, since we are now performing operations so radical that extension of the operation is scarcely possible anatomically. However, we can and should devote more thought to prophylactic measures such as minimizing the spread of cancer during an operative therapy. I have called attention to some of these features elsewhere, particularly in the field of cancer of the colon.

There appears to be little doubt that an unsuccessful attempt to remove a tumor will disseminate the tumor and shorten the life of the patient. Unfortunately, there will be occasions during the life of every surgeon when he will be unable to determine inoperability before a surgical attempt is made to excise the tumor. However, in order to minimize the development of this unfortunate deleterious effect, we should make all effort to detect inoperability before the operation is started. We must admit also that in certain tumors the five-year survival rate is too low to justify a radical operative procedure with a high mortality rate. Conforming to this philosophy, we have already ceased operating on patients with carcinoma of the head of the pancreas unless the patient is quite young and the tumor a very early one. The time appears to be approaching soon when we will abandon the conventional operation of bringing the stomach up to meet the esophagus after excising carcinoma of the middle third of the esophagus, because the operative mortality rate is so high and the five-year survival rate so low. We already have operative procedures which are much simpler and require no more than half the operative time con-

sumed in the conventional esophagogastrostomy; moreover they eliminate just as much tissue surrounding the tumor. I predict that simpler measures will be improved sufficiently to replace the conventional esophagogastrostomy now being performed for middle-third lesions.

Fortunately the unsatisfactory results mentioned in the preceding paragraph occur in so few types of cancer that we need not and must not develop a fatalistic attitude about cancer. Results in the majority of types of cancer following radical resection and/or radiation therapy are so favorable that we can truthfully give our patients an optimistic answer to their questions concerning prognosis, provided we see the patient before obvious invasion has extended beyond our line of resection. Accordingly, we must not allow a fatalistic attitude to develop, and must urge our patients to go to a doctor within a few days following onset of symptoms suggestive of a neoplasm, rather than wait several months hoping the lesion producing the symptom is harmless. To achieve this optimum status we must inform the laity concerning dangerous symptoms and urge them to seek medical aid and advice immediately. If they are not so informed fatal delays in therapy will be too frequent.

Many physicians are so worried about the production of cancerphobia by a policy of lay education that they apparently oppose this type of education. However, the author is not at all concerned about this possibility, because he has seen very few people with cancerphobia which could not be dispelled by a negative examination and a proper interview with the patient. If the cancerphobia cannot be dispelled, the patient is usually so unstable that he would maintain a phobia or worry of some other type, anyway. After all, we want the patient to have a healthy fear of cancer otherwise he may be too slow to consult his physician about manifestation of cancer, particularly since so many of them are insidious.

Accordingly, we can offer a favorable prognosis in most cancer, if therapy is undertaken soon after development of manifestations. When the patient is seen too late to expect surgical or radiation therapy to be effective we must then resort to the palliative measures and psychological mechanism. One of these psychological mechanisms too seldom used relates to the spontaneous regression of cancer. Although spontaneous cure of cancer is extremely uncommon, spontaneous regression is less rare and has been noted by practically all physicians. Furthermore, delay in development of metastases and slow growth of metastases is extremely common. By telling the patient that tumors sometimes stop growing and even disappear, this phase of cancer inactivity can be utilized in allaying the patient's fear even after metastases have been recognized by the patient as evidence of recurrence.

We should likewise make more effort to correlate these examples of regression or slow growth of the tumor in our cancer research. True enough, we do not know the cause of this regression or slow growth, but each would appear to be related to an immune factor in the patient's body. We now have fairly good evidence that the body can elaborate specific antibodies against

cancer. In certain patients with cancer an elevation of globulin and fibrinogen is encountered, but the level decreases as the malignant invasion becomes more extensive. Antigens have been extracted from tumor tissue in efforts to develop tests for cancer, but as yet none of these tests is reliable. Recently, antibodies have been found in certain patients with early cancer but not in patients with advanced cancer (Graham and Graham). This suggests that antibodies may be an important influence in growth or destruction of cancer. At any rate this immunological phase of cancer research appears to be about as important as chemical therapy from the standpoint of cancer research. Both should in time yield significant results.

—*W. H. Cole.*

Appraisal of Progress in Surgical Therapy

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INTERNAL FIXATION OF FRACTURES

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THE internal fixation of fractures has remained a controversial subject since the turn of the century when it was first popularized in America by Arbuthnot Lane. His advocacy of this method of treatment received wide acclaim, but many surgeons, blinded by the fascinating possibilities of the technique, overlooked or quickly forgot the principles upon which Lane had predicated its success. As a result, internal fixation was adopted widely and with such indiscriminate enthusiasm that soon it became damned by misuse. But, a small group of American surgeons accepted the new form of treatment with more reserve, used it with caution, gradually became cognizant of its inherent advantages and defects, and progressively evolved a valid philosophy for its use. In their hands internal fixation, which had almost been an infant mortality, developed into a healthy child. At the onset of World War II it was a flourishing adolescent, not yet mature enough for military service, and still the object of frequent criticisms by many surgeons who found themselves unable to comprehend or control its caprices.

The end of the war coincided with the advent of chemotherapy and a resulting temporary euphoria that the battle against infection was also won. An important detriment to the prewar widespread use of internal fixation, the fear of infection, seemed to have been removed. Almost overnight surgeons who had condemned the method most vehemently became its staunch advocates. Once again internal fixation of fractures became unduly popular and the waters of clear thinking soon were muddied by a confusion of conflicting ideas concerning its use. Despite the resulting chaos of small arguments, the basic principles of fracture treatment and the proper role of internal fixation in their implementation have remained unchanged.

RECONCILIATION OF METHOD AND PRINCIPLES

The outmoded idea that the treatment of fractures could be epitomized by the dictum "replace the bone ends together and immobilize the limb in

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plaster until the fracture heals'' is no longer tenable. Modern treatment must remain predicated upon a valid concept of the dynamics of pathology and repair, and the associated mechanical problems attending every injury. This requires comprehension that a fracture is not a ''broken bone,'' but a localized area of damage to all the other tissues as well, which, secondarily, has a profound effect upon all the neighboring undamaged structures to the final physical, economic, and psychic detriment of the entire individual. Also required is comprehension that the ultimate goal of treatment is not altogether sound bony union, full strength, complete mobility, normal anatomy, nor an absence of symptoms. These features of the result are all desirable, but not always attainable. Frequently one or more must be compromised in order to obtain others more important. The surgeon's ultimate goal is a return of the patient to his usual activities as soon and as nearly normal as possible. This goal is possible only by adherence to 3 cardinal principles.

1. *A reduction* which inflicts a minimum of additional tissue damage.

2. *Fixation* which interferes to a minimum with continued function of the regional undamaged structures.

3. *Function* throughout healing, not only of the injured region, but also of the patient as a whole.

Internal fixation is consonant with these principles. Carried out with precise dissection and gentle handling of the tissues there can be no doubt that operative exposure and reduction of a fracture is attended by less tissue damage than is caused by any form of manipulative reduction. Properly applied to a suitable fracture there can be no doubt that internal fixation is more certain and secure than any form of external dressing. Nor can there be any doubt that internal fixation most nearly approaches the ideal in making possible a maximum maintenance of function throughout the healing period. But, the penalties of a technical defect in the application of internal fixation or of infection following the operation remain so great as to place stringent limitations upon the use of this method, except by well-trained surgeons in an immaculate surgical environment and when the indications are unassailable.

THE INDICATIONS FOR INTERNAL FIXATION

The indications for internal fixation embrace but a very small percentage of all fractures, and often depend as much upon the regional or systemic features of the problem at hand as upon the roentgen characteristics of the broken bone. Briefly stated, internal fixation may be required by absolute necessity, justified by relative necessity, or occasionally permissible as a method of election.

Absolute necessity exists only as a life-saving measure, or when reduction cannot be maintained by any other method.

Relative necessity applies when internal fixation promises a more rapid, better, or certain result than seems possible by any other method, or promises to obviate some serious disadvantage of other methods.

As a treatment of choice internal fixation is sometimes permissible when, as a calculated risk and under ideal circumstances, it promises a reduction of morbidity and disability time sufficient to neutralize the risk.

Despite the simplicity and clarity of these indications for its use, internal fixation remains the subject of more dogmatism and controversy than almost any other surgical procedure. That the process of bone healing remains an enigma precluding certain substantiation or rebuttal of adverse postulates creates fertile grounds for dogmatism, Many of the current controversies stem from a failure to delineate the basic premises and pathologic circumstances underlying the points at issue. Others, shaded by individual concepts of the various factors influencing the healing of bone, are concerned with the details of tools or technique, and assume a subordinate role in the light of fundamentals.

ON THE TIMING OF INTERNAL FIXATION

It is variously argued that open reduction and internal fixation of a fracture should be done: (a) as soon as possible, (b) not until the patient has recovered completely from shock, (c) not until after several days of assessment and multiple preparations of the skin, and (d) only as a last resort after the failure of nonoperative methods. An examination of the fundamentals of injury and repair leaves little room for argument.

The tissues of the injured area are in optimum condition for operation at the moment of wounding and deteriorate inexorably for many days thereafter. That an undesirable delay is sometimes mandatory pending the control of a skin condition or the reduction of tissue tension resulting from neglect does not alter this physiologic fact. Multiple preparations of the skin cleanse more thoroughly than one, but consume a period during which the deeper tissues become tense, edematous, and devitalized, hypoxic from thrombosis and stasis, and almost devoid of resistance against infection. Shock is a relative term, subject to individual interpretation and demanding the utmost in mature surgical judgment for accurate assessment. It is not only the systemic response to injury, but also is augmented and perpetuated by an untreated injury. The fractured femur demanding internal fixation will require anesthesia, an incision of little but skin and fascia, hemostasis, the evacuation of large quantities of extravisated blood and plasma-like fluid, gentle replacement and fixation of the fracture fragments, and closure of the wound. Except when shock is profound, it is clear that each of these measures required for the fracture, if done gently and accompanied by good anesthesia and adequate supportive therapy, will serve but to remove the primary and perpetuating causes of the systemic collapse.

A concept that internal fixation should be used only as a last resort reflects either a lack of confidence that it can be done safely and well, or an ignorance of the dynamics of wound repair and a failure to comprehend that the additional tissue damage inflicted by repeated unsuccessful manipulations and the passage of time militate against the prospects for success with internal fixation, or any other form of final treatment. Clinical experiences overwhelmingly vindicate

the contention that under appropriate auspices, given skin that can be cleansed and shock that can be controlled, internal fixation should be done as soon after the injury as possible.

CONCERNING LANE TECHNIQUE AND THE RISK OF INFECTION

Lane promulgated an operative technique in which none of the surgical team ever touched the tissues or any portion of an instrument or suture which entered the wound. This was designed to promote the utmost in asepsis, and undoubtedly played an important part in the reduction of infections in an era when surgical asepsis was in its infancy. But, operative technique and asepsis have made great advances since the time of Lane, and his nontouch technique cannot be perfected without a long period of supervised practice. It is quite clear that modern American surgical training facilities boast of few qualified instructors, fewer services where a nontouch technique is organized and practiced, and almost no residents who spend enough continuous time in the surgery of trauma to become proficient in its use. On this Service, prior to World War II, a strict nontouch technique was scrupulously enforced and the operations were done by senior surgeons. Subsequently, with the evolution of resident training, the operations have been done by junior surgeons who were competent in modern surgical technique, but unversed in the intricacies of Lane's exacting discipline. There has been little difference in the incidence of postoperative infections above and beyond that attributable to the relative maturity of the surgeons involved.

Despite steady improvements in operative technique and adjuvant chemotherapeutic measures, the operative treatment of fractures remains attended by an infection risk greater than that existing in any other branch of clean surgery. The fracture cavity is lined by damaged fascia and muscle, and encloses a collection of blood and plasma-like fluid which has, suspended throughout it, many particles of dead bone and soft tissue. The area is said to be hyperemic, but this is a passive congestion. The decomposing puddle of protein garbage is stagnant and remains relatively unaffected by vascular and lymphatic flow for a considerable period. No infection restraining, membrane-like peritoneum limits this ideal bacterial pabulum, and the passage of time and increasing tissue devitalization rapidly increases its potential as a culture medium. Inadequate asepsis, rough handling of the tissues, incomplete hemostasis, or any of the other common technical defects of the careless or inexperienced surgeon who dares to innoculate such a hazardous area are open invitations to catastrophe. While Lane's nontouch technique is usually impractical, the highest possible degree of modern aseptic technique is unremittently mandatory to the avoidance of postoperative infection.

ON THE PHYSICAL AND METALLURGICAL CHARACTERISTICS OF THE MATERIAL USED FOR INTERNAL FIXATION

Discussions concerning the optimum composition and physical strength of internal fixation material have been voluble and heated. Obviously the ideal material is not yet available. This will be completely inert to the chemistry of the body fluids, light in weight, small in volume, strong and tough, yet

malleable, and with a resilience to withstand prolonged fatigue strain. Futile standardization of the available materials by shear and torque tests and breaking point measurements fails to recognize that in clinical practice breakage of the material almost invariably results from faulty application or from fatigue strain following prolonged exposure to the elastic forces of living tissues.

The alloy Vitallium and 18 and 8 SMO stainless steel are in common use. The alloy is chemically inert, but, by clinical comparison, neither as tough, malleable, or resilient as stainless steel which displays some eventual tissue reaction. Both have proved satisfactory, except when misused. The two common defects of internal fixation, breakage and tissue reaction, depend much more upon the manner of insertion than upon metallurgical composition. The screw that is not plumb or is over-tightened until the bone thread is broken, the plate that has not been fitted exactly to the contour of the bone or is too short for its intended task, the tight wire suture that produces bone necrosis, the loose intramedullary device, or any of the other technical defects of application which predispose to a concentration rather than a dispersion of stress are the common and primary causes for breakage of fixation and absorption of bone. Conversely, the incidence of these two complications is negligible when either Vitallium or stainless steel devices are applied with precision and an adequate distribution of the load to be carried.

ON THE AMOUNT OF INTERNAL FIXATION—"INTERNAL SUTURE OR RIGID FIXATION"

One school of thought contends that the amount of internal fixation implanted in a fracture should be the least that will assure approximation of the bone ends, and that supplemental external immobilization should be used to maintain the reduction. Another advocates the use of sufficient internal fixation to obviate or minimize the need for supplemental external immobilization. Neither of these tenets is valid as a dogma, but there is a place for each in the internal fixation of fractures.

Internal fixation by necessity is essentially "making the best of a bad job that could not be done at all by other methods." Secure stabilization of the bone fragments is often impossible so that supplemental external immobilization becomes mandatory. Under such conditions it would be illogical to implant more foreign material than is necessary to maintain the reduction until plaster-of-Paris dressings can be applied. Necessity would demand acceptance of the risks of the operation and the penalties of surgical obliteration of function throughout the healing period. But, the fracture internally fixed by election does not justify such double jeopardy. Elective internal fixation denotes an acceptance of the operative risks in return for a reduction of morbidity and disability time, despite the availability of safer methods which would produce a delayed, but equally satisfactory, end result. Under these conditions the use of sufficient internal fixation to obviate or minimize the need for external splints often is a good clinical bargain, for unless physiologic function of the part can be maintained safely throughout the healing period, the elective operation is a failure. There can be little doubt that secure and rigid internal fixation most

nearly satisfies the therapeutic prerequisites implicit in the basic principles of fracture treatment, but it is equally clear that when secure fixation cannot be accomplished the less foreign material implanted the better.

ON THE INTERNAL FIXATION OF OPEN FRACTURES

The implantation of foreign fixation material into a contaminated open fracture is condemned by some and commended by others who have practiced this treatment successfully in selected cases for many years, both preceding and throughout the chemotherapeutic era. The crux of this argument centers around the selection of cases and the quality of the surgical technique employed. The proper selection of cases requires a delicately balanced judgment. Given an adequately excised and cleansed wound, treatment of the fracture by traction or plaster splints usually is attended by constant small movements of the devitalized bone ends in the depths of a contaminated wound. In many cases this creates a greater infection risk than would the implantation of an additional foreign but sterile element in return for stability of the whole. Internal stabilization of the bone fragments greatly facilitates subsequent skin coverage, secondary closure, or dressings. It has been practiced in selected cases on this Service for twenty-seven years, during which time no lives and only 4 extremities have been lost due to infection. Internal fixation of an open fracture is always a calculated risk, but when elected by mature surgical judgment and used with skill, it is of inestimable benefit to the management of many otherwise vexing problems.

ON THE THEORY OF "CONTACT COMPRESSION"

It is well established that distraction of fracture fragments is detrimental to the process of bone healing. The possibility that the reverse of distraction (compression) might be helpful has set the stage for the most heated argument about fracture treatment in recent years. The late Albert Key utilized compression in the treatment of fractures many years ago, but was apparently unimpressed by any physiologic effect. Eggers carried out experiments in which membranous bone (the skulls of rats) appeared to heal more rapidly under the influence of elastic compression. Charnley educed evidences of accelerated union of cancellous bone under measured turnbuckle compression. The case for any beneficial effect of compression upon the healing of cortical bone has not been documented. Nevertheless, surgeons in many countries are applying the conclusions drawn from spongy bone experiments to the internal fixation of long bone (cortical) fractures. Watson-Jones and many others vehemently subscribe to the notion that mechanical compression of fracture fragments can produce little except an increased security of contact, and some necrosis of the compressed bone ends. The jury is still out, but the clinical center of this argument, the slotted plate, is worthy of examination exclusive of the physiologic concepts involved.

The slotted plate was designed to accommodate the concept that, unless internal fixation allowed the bone ends to remain compressible by muscle tone, a gap would occur at the fracture due to absorption of bone from each fragment. However, when such a plate is molded to the contour of the bone and fastened tightly enough to produce secure fixation no such compression is possible; and

when fastened loosely enough to permit compression the fixation provided is loose and insecure. Furthermore, objective studies have revealed but 3 common reasons for the absorption of bone from the ends of internally fixed fracture fragments, namely, infection, motion, and fixation in distraction. The use of a slotted plate unquestionably permits the occasional fracture surgeon a greater margin for error in application, and the nonslotted plate must be applied with great precision or not at all. The bulk of present evidence suggests the incidence of success and failure attending the use of either type to be identical and proportionate to the judgment and competence of the surgeon.

INTRAMEDULLARY FIXATION

Intramedullary internal fixation for fracture of the neck of the femur was used by Nicolayson in 1897, and popularized by Smith-Petersen in 1931. The present almost universal use of some form of medullary fixation for most hip fractures has produced results which constitute probably the greatest advance in fracture treatment accomplished by the present generation of surgeons. No longer is the elderly person with a hip fracture condemned to many months of bed stay enforced by pain and a large plaster-of-Paris dressing or a cumbersome traction apparatus. No longer is the hip fracture inevitably productive of severe morbidity attended by many complications and little hope for satisfactory rehabilitation, and previous mortality rates in excess of 33 per cent have been reduced to about 5 per cent for fractures of the femoral neck and 15 per cent for more comminuted trochanteric lesions. The high incidence of late avascular necrosis of the femoral head remains unaffected, and the complication of nonunion remains exceedingly frequent, despite the stabilization of cervical fractures provided by this form of fixation. It is clear that the advantages resulting from the internal fixation of a hip fracture benefit the systemic rather than the local effects of the injury. It is equally clear that the fracture must be stabilized as soon as possible and the patient mobilized quickly following the operation if physiologic stagnation is to be prevented in the geriatric patient and the best results obtained. The many medical complications common to the aged patient, with the exception of certain cardiac arrythmias and uncontrolled diabetes with acidosis, cannot be helped promptly enough to justify more than a few hours delay in operation, but must be evaluated and controlled coincident with fixation of the fracture. Experience has proved consistently that the incidence of complications and the severity of the postoperative morbidity are doubled following delayed operation by comparison with operation carried out within twenty-four hours after the injury, and that only by early and continued postoperative mobilization can the general physiologic mechanism of the average elderly patient be maintained on an even keel. These all important factors in the reduction of morbidity and mortality following hip fracture in the aged have been possible only after prompt and secure medullary fixation of the local lesion.

Intramedullary fixation for long bone fractures was done by Hey-Groves in 1916, but did not become widely used until 1939 following the work of Kuntscher. As with many other advances in medicine this form of fracture treatment has passed through an evolutionary phase attended by misuse and overuse, and its optimum form and place in the field of fracture treatment is

not yet fully established. Nevertheless, it promises to be one of the most efficient forms of internal fixation yet employed. The fear of serious damage to the hemopoietic system by obliteration of large medullary canals has not been sustained. While bone union occurs in fractures stabilized by medullary devices at least as rapidly and as frequently as with other methods of fixation, this form of treatment is not, as is sometimes contended, the entire solution of the problem of fibrous union. Nonunion continues to occur despite the most secure fixation by intramedullary devices.

The greatest benefits resulting from widespread use of intramedullary fixation include a marked reduction of morbidity following major long bone fractures treated in this manner. The patient with a fracture of the shaft of the femur is able to leave the hospital walking with crutch support within several weeks after injury. Pathologic long bone fractures stabilized by some intramedullary device remain comfortable and mobile pending the outcome of the bone disease. Fractures of the adult forearm can be stabilized without the tissue insult formerly necessary to the application of plates and screws to the surface of the bones, and a resultant significant decrease in the incidence of malunion and nonunion seems reasonably certain. Medullary fixation of fractures of the shaft of the tibia is more dangerous and difficult than in other bones, but recent contributions by Lottes promise an eventual solution to this vexing problem.

The advantages of intramedullary fixation remain somewhat neutralized by the present evolutionary state of the technique for its use. The numerous and sometimes catastrophic accidents potential to the casual insertion of an intramedullary element militate against this method of fixation except in the hands of a skilled surgeon who is aware of the pitfalls as well as the advantages.

SUMMARY

Internal fixation has weathered the tests of time and use, and has been proved to be a method of fracture treatment consonant with fundamental surgical principles. When properly used in suitable circumstances many otherwise unattainable results can be secured. Fixation materials and devices have been developed to a high degree of efficiency. Modern anesthesia and asepsis have reduced the risk of operative mortality and postoperative infection. It remains for the surgeon to improve his judgment and operative technique to a point where the maximum benefits from internal fixation can be obtained.

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Calendar of Surgical Meetings

THE AMERICAN ACADEMY OF NEUROLOGICAL SURGERY. *Annual Meeting*, Nov. 1-3, 1956, Camel Back Inn, Phoenix, Ariz. Secretary, Eben Alexander, Jr., M.D., Bowman Gray School of Medicine, Winston-Salem, N. C.

AMERICAN ASSOCIATION OF GENITO-URINARY SURGEONS. *Annual Meeting*, June 4-6, 1956, Oyster Harbor Hotel, Osterville, Mass. Deadline for papers, Feb. 10, 1956. Secretary, John A. Taylor, M.D., 2 East 54th St., New York, N. Y.

AMERICAN ASSOCIATION FOR THE SURGERY OF TRAUMA. *Annual Meeting*, Oct. 4-6, 1956, The Biltmore, Santa Barbara, Calif. Deadline for papers, July 1, 1956. Secretary, James K. Stack, M.D., 700 N. Michigan Ave., Chicago 11, Ill.

AMERICAN CANCER SOCIETY, INC. *Third National Cancer Conference*, June 4-6, 1956, Sheraton Cadillac Hotel, Detroit, Mich. Coordinator, Brewster S. Miller, M.D., 521 West 57th St., New York 19, N. Y.

AMERICAN COLLEGE OF SURGEONS. *Clinical Congress*, Oct. 8-12, Civic Auditorium, San Francisco, Calif. Secretary of the College, Michael L. Mason, M.D., 154 E. Erie St., Chicago 11, Ill.

THE AMERICAN GASTROSCOPIC SOCIETY. *Annual Meeting*, June 10 and 11, 1956, Knickerbocker Hotel, Chicago, Ill. Secretary, C. Wilmer Wirts, M.D., 1025 Walnut St., Philadelphia, Pa.

AMERICAN GYNECOLOGICAL SOCIETY. *Annual Meeting*, May 21-23, 1956, The Shoreham, Washington, D. C. Secretary, John I. Brewer, M.D., 104 S. Michigan Avenue, Chicago, Ill.

AMERICAN MEDICAL ASSOCIATION. *Annual Meeting*, June 11-15, 1956, headquarters, Navy Pier, Chicago, Ill. *Clinical Session*, Nov. 27-30, 1956, Civic Auditorium, Seattle, Wash. Deadline for papers, Aug. 1, 1956. Secretary, Council on Scientific Assembly, A. M. A., 535 N. Dearborn St., Chicago 10, Ill.

THE AMERICAN ORTHOPAEDIC ASSOCIATION. *Annual Meeting*, June 16-20, 1956, Banff Springs Hotel, Banff, Alberta. Secretary, George O. Eaton, M.D., 4 East Madison Ave., Baltimore, Md.

AMERICAN UROLOGICAL ASSOCIATION. *Annual Meeting*, May 28-31, 1956, Statler Hotel, Boston, Mass. Secretary, Samuel L. Raines, M.D., 188 S. Bellevue Blvd., Memphis, Tenn.

LATIN AMERICAN CHAPTER OF INTERNATIONAL SOCIETY OF ANGIOLOGY. *Third Meeting*, Nov. 8-11, 1956, Havana, Cuba. President, Armando Núñez Núñez, Calle 25 No. 510, Vedado, Havana, Cuba.

NEW ENGLAND SURGICAL SOCIETY. *Annual Meeting*, Oct. 5 and 6, 1956, Poland Springs House, Poland Springs, Maine. Deadline for papers, June 1, 1956. Secretary, Richard Warren, M.D., Peter Bent Brigham Hospital, 721 Huntington Avenue, Boston 15, Mass.

THE SOCIETY FOR VASCULAR SURGERY. *Annual Meeting*, June 10, 1956, The Conrad Hilton, Chicago, Ill. Deadline for papers, March 15, 1956. Secretary, Henry Swan, M.D., 4200 E. 9th Ave., Denver, Colo.

SOUTHERN SURGICAL ASSOCIATION. *Annual Meeting*, Dec. 4-6, 1956, the Boca Raton Club and Hotel, Boca Raton, Fla. Deadline for papers, Sept. 20, 1956. Secretary, George G. Finney, M.D., 2947 St. Paul St., Baltimore, Md.